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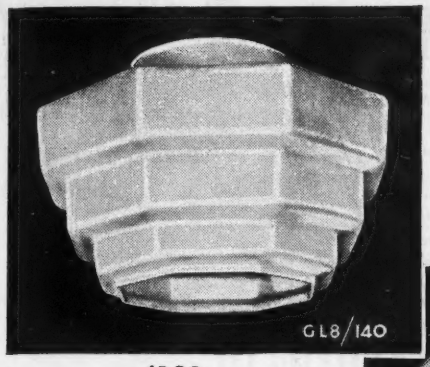

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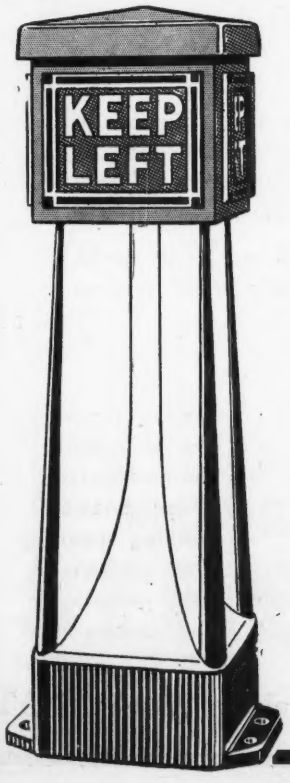

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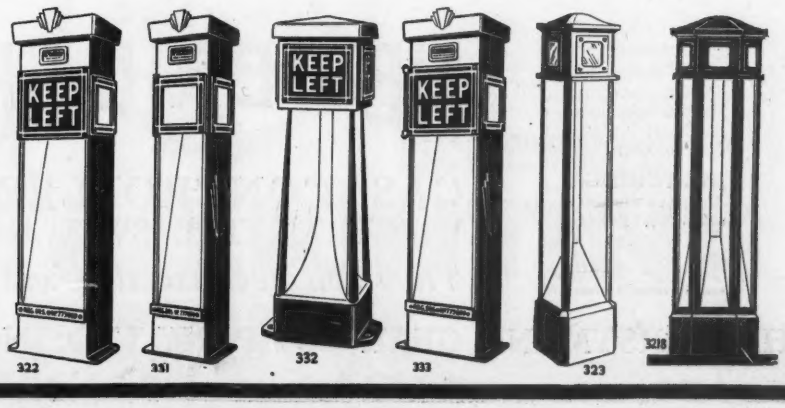

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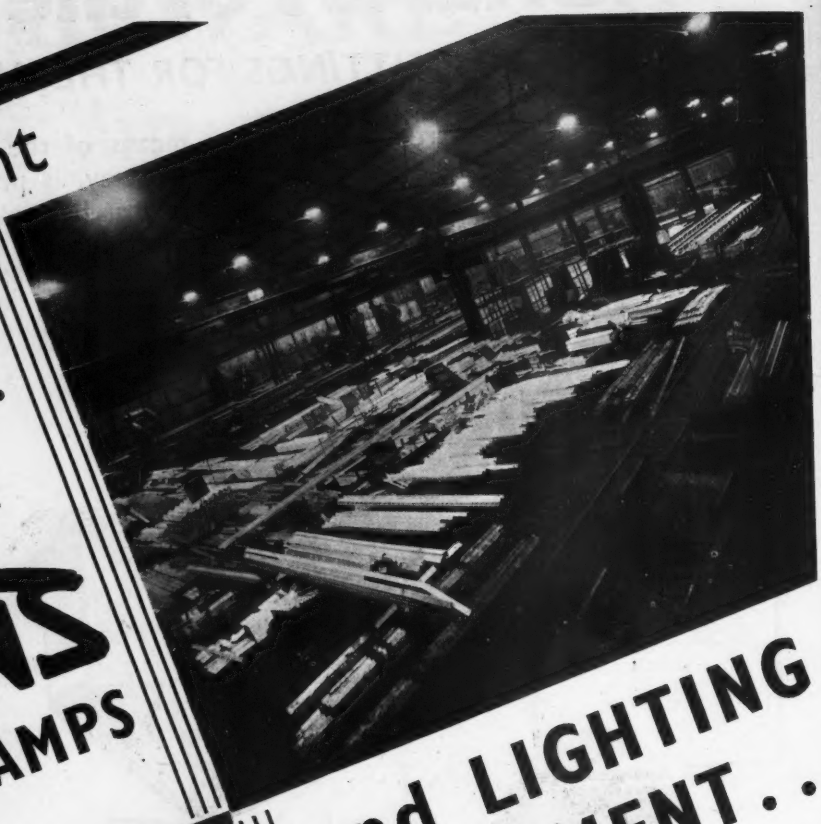

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FOUNDED IN LONDON 1909
INCORPORATED 1930

The ILLUMINATING ENGINEER

THE JOURNAL OF GOOD LIGHTING

Edited by

J. STEWART DOW

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This Luminous Sign Controversy.

MR. GUY DAUBER has recently deplored in *The Times* the increasing use of luminous signs in London. In Paris, in the vicinity of the Arc de Triomphe and elsewhere, visual publicity is now forbidden. In New York there are no signs in Fifth Avenue, though Broadway is ablaze with them.

The reasons for this wholesale banning of a most useful type of lighting are twofold—firstly, there are those who object to the lighting from an aesthetic point of view. Then there are the authorities who consider the existence of these lights (particularly those which are red, i.e., neon) to be dangerous to traffic.

As in the case of most controversial topics, there is a deal to be said for both sides of the question.

What, however, can be done to reconcile the various conflicting ideals?

We suggest the formation of an Advisory Committee on which such bodies as the Royal Institute of British Architects, the Illuminating Engineering Society, and the Master Sign Makers Association should be represented. Such a Committee might suggest reasonable limits in regard to position, colour, and brilliancy which would meet the wishes of the public. It might also do something to smooth out the extraordinary tangle of restrictions prevailing in different towns, many of them obsolete and useless—and by so doing earn the undying gratitude of the sign-maker.

Construction Work by Night

Mr. Cunnington's paper on portable illuminants has brought me some comments on the ease with which night-shifts in connection with outdoor construction work can now be run. Acetylene flare and incandescent oil lamps have proved their worth for this purpose. Perhaps also the use of compressed gas in this connection will soon be familiar. Where electricity is available floodlighting of such work is quite usual. Some striking illustrations are to be seen in a recent issue of " l'Illuminazione." One need not, however, go abroad for such instances. My correspondent draws attention to the work in progress on the western wing of the Bank of England, recently the subject of comment in the " Evening News." The great cavity below street level is brightly lighted and work goes on incessantly. Above, two very tall cranes, the working platforms of which are higher than neighbouring buildings, are at work. The illuminated cabins, apparently floating in mid-air, have a strange effect at night. As our contemporary remarks: " It must be mighty cold up there! "

When High Illumination is not *Desired*

It may be pointed out, however, that although the interiors of such lighted cabins naturally appear bright to persons standing in darkness, they do not, as a rule, need or receive very much light. In this respect the crane-cabin is not unlike the signal cabin on a railway (a railway above ground that is; the conditions in tube railways are perhaps somewhat different). The operators in such cases need a certain amount of diffused light in order to see the dials of instruments; but a very high general illumination, and especially exposed sources of light would seriously interfere with the observation of objects in the darkness outside. Such " reversed contrast," whilst not exactly constituting glare does interfere with ease of vision. Hence one finds that operators in signal cabins habitually use only local screened lamps to illuminate essential instruments or apparatus (taking special care to place them so as to avoid reflected images), and for general lighting are content with the feeble diffused light that escapes from them.

" Certified " Hotel Lighting

We notice in the transactions of the Illuminating Engineering Society (U.S.A.) a reference to an enterprising move by certain hotels, which announce that they now provide " certified " lighting for every guest room, the adequacy of which is guaranteed. The certificate is apparently based on the ease with which various kinds of type can be read—a somewhat difficult method of assessment one would think—but the idea is admirable. We assume that certified lighting would at least furnish each guest with a shaded lamp at his bedside and would ensure him against having to get out of bed and fumble for a switch in the middle of the night—an obligation, we are sorry to say, still too often neglected in otherwise quite adequate hotels!

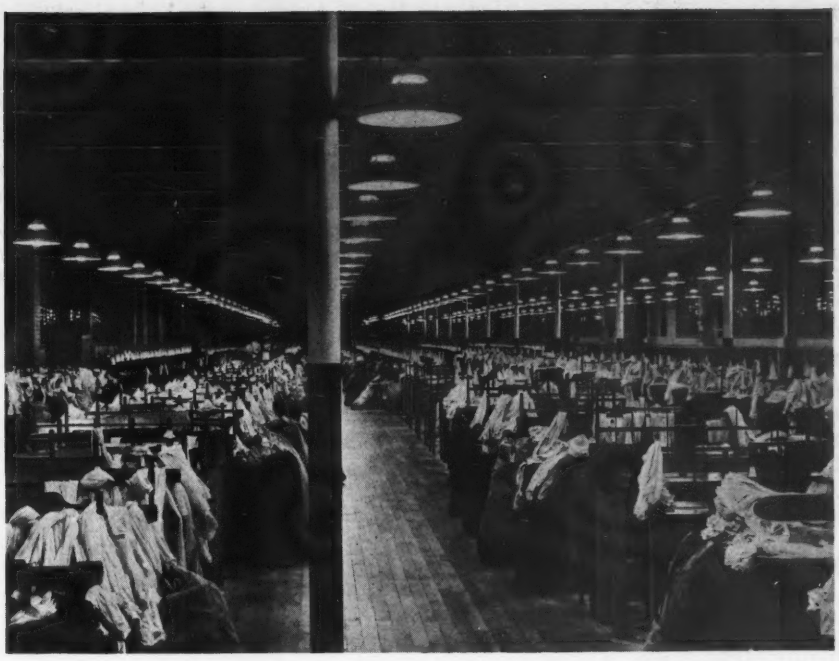
Illuminating Engineering in Australia

I have been favoured by Mr. Leslie Robertson, the Chairman of the Education Committee of the Illuminating Engineering Society of Australia (Victoria Division) with a copy of the annual report of this body. It should be explained that in Australia there are two divisions of the I.E.S.A., governed by separate councils and distinct bodies, though in close touch with each other. (This may seem a somewhat singular arrangement—but only until the vast distances between industrial centres in Australia are remembered.) The account of the work of the Victorian division makes interesting reading. Although the membership is at present less than 100, the Society makes up in enthusiasm anything it lacks in numbers. It is to be congratulated on holding its own and carrying on during the period of depression—now happily passing. H.R.H. Prince George's visit, and the forthcoming centenary celebrations in Melbourne, are being awaited with keen interest.

Working on Parallel Lines

During the past session an excellent series of papers has been read. It is interesting to see how certain topics much discussed at home, such as the merits of directional and non-directional street lighting, appear in the list. In other respects the movements in this country and in Australia seem to be proceeding on parallel lines. One notices for instance, the efforts being made to secure attention for illumination in University curricula, the decision to enroll " student members," and the initiation of informal discussions of the " have at thee " character, which seem to have proved a notable success. The publication of transactions is naturally beyond the means of the Society, but it is stated that a very satisfactory arrangement has been entered into with the " Australian Engineer," in which papers will be published, and which will be circulated to all members. This step, it is believed, will greatly assist the formation of a class of student members.

Good Industrial Lighting No. 2.



Courtesy Messrs. Benjamin Electric Ltd.

How to Secure Sufficient Illumination

IN our last number we set ourselves to answer the question "What Constitutes Good Industrial Lighting?"*

It was shown that there are six main principles that *always* need to be considered (namely, (1) Sufficiency of Light, (2) Reasonably Uniform Illumination, (3) Absence of Glare and Dazzle, (4) Avoidance of Inconvenient Shadows, (5) Constancy of Light, and (6) Proper Maintenance of Light); and about five others (such as colour of light, etc.), which often, but not always require study.

We shall now deal with the first and second of these points by answering the further query: **"HOW TO SECURE SUFFICIENT ILLUMINATION?"**

Let it be clearly understood, however, that this is only *one* of the requirements of good illumination. Obviously, the very first thing, if one is to do one's work efficiently, is to have sufficient light. But this alone is not enough. High illuminations—even 50 foot-candles or more—are of no avail unless the eye can make use of them. If glaring sources are present the eyes become distressed. They may derive less benefit from this high value than they would from one-twentieth of the same amount of light, if furnished by properly shaded lamps.

Care For the Eyes First!

Another thing—the eyes must themselves be in a condition to benefit by the light provided. Good illumination does undoubtedly make matters easier for people with indifferent sight. But it cannot *cure* defects of vision. If, for example, eyes are so short-sighted that they cannot bring fine type into focuss, or so astigmatic that a criss-cross pattern becomes a blurr—no amount of light will enable such people to see clearly. The very first thing is to consult the oculist and obtain glasses to correct these defects. Then the full benefit of the good illumination is obtained.

This point is mentioned because in almost every factory a few workers will be found—usually the older ones—who habitually complain of the illumination and call for light and yet more light! It will almost invariably be found in such cases that the grumbler has sub-normal vision, and that the provision of glasses, to correct defective eyesight, is the real remedy and not more light. One can, however, easily understand how this demand arises when one considers that a very high illumination (or the presence of glare!) does cause a certain contraction of the pupil-aperture, which improves the power of seeing just as the stop on a camera gives better definition of the image.

(Thus we see that the popular impression that a wide open pupil, admitting most light to the eye, is an advantage, is not necessarily correct!)

Moreover, it is not only those whose eyesight is poor who need spectacles. In certain occupations—"hosiery linking" is a conspicuous example—the strain of constant close examination of minute objects may be too much even for good eyes. Magnifying spectacles have been found to be of great benefit in such cases in relieving eyestrain and improving quality and output of work.

Where Light is Needed.

The next point that arises is where the light is needed, and where, therefore, it should be measured. Obviously, the most vital place is the spot on which the work is done—usually a bench or table. Hence it is usual in dealing with the lighting of a room as a whole, to define as the "working plane," the level of the average table, and to measure horizontal illumination at a height of two and a half feet above the floor.

This consideration usually meets requirements in rooms where all the workers are sitting at regular intervals and engaged on identical tasks. If the illumination on the working plane is everywhere sufficient, the

* Illum. Eng., March, 1934, pp. 71-73.

room as a rule may be considered well lighted. Nevertheless, the place where light is most necessary may be some special one, i.e., the point of a tool at the lathe, an inclined surface gripped in a vice, or a vertical rack mounted on the wall. It will almost invariably be found that if the horizontal illumination is sufficient the vertical illumination is ample. Still, this point does deserve thought, and suggests one reason why it is usually preferable to adopt for general lighting fittings which direct a fair amount of light sideways and not only a concentrated downward beam illuminating a narrow area. Moreover, whilst emphasis is placed, quite rightly, on the illumination over the working area, we must always remember that the other parts of the room also need a moderate amount of light, in order to avoid a depressing effect, and also in order that people may be able to move about with ease and comfort.

A Table of Foot-Candle Values.

In the accompanying table the requisite illumination has been tabulated in four main divisions. Complicated schedules, which attempt to specify the exact illumination needed for a multitude of operations are sometimes offered. But there is really no object in discriminating so closely as this. An intelligent works manager or works engineer should have little difficulty in deciding in which of these four categories a task should fall; or in deciding how far he will travel from the upper or lower limit, according to the severity of the local conditions. Most industrial operations fall into Division III., and there are not many jobs that cannot be done well with an illumination of the order of 8-10 foot-candles. Some need less, and some kinds of intricate and difficult work may need more—in which case it will usually be found expedient to furnish extra light by means of local units.

It must be remembered that in this country there are as yet no official standards of working illumination, though in 1921 a Departmental (Home Office) Committee on Lighting in Factories and Workshops suggested 3 and 5 foot-candles as minima for "fine" and "very fine" work respectively. Such minima ought, naturally, to be exceeded in good working practice, on which the table is based. Division I. gives some indication of the kind of illumination that should be maintained in a "non-working" area, i.e., in parts of a room where people move to and fro constantly, but where no actual task is undertaken. The writer would suggest, as a practical rule, that in such areas not less than 1 foot-candles should be provided.

VALUES OF ILLUMINATION FOR INDUSTRIAL WORK.

Nature of Work or Interior.	*Illumination in Foot-Candles.*
I. Corridors, Store Rooms, and Spaces not devoted to working operations.	1 — 2
II. Packing, Assembling, and Rough Operations.	2 — 5
III. Clerical Work, and Fine Operations.	5 — 10
IV. Very fine operations, or work on dark materials, frequently involving special local lighting.	10 — 50

The most economical arrangement is that in which a maximum of light is directed on the actual working area. It does, however, aid in producing a cheerful effect and also assists the diffusion of light if fairly bright ceilings can be secured. If the ceiling is very dark in colour, very high, or composed mainly of glass, there is little object in illuminating it strongly. But if it is reasonably light in colour an illumination of, say, 0.5 foot-candles is judicious even with the most severely economical downward direction of light. When general lighting from lamps in diffusing glassware is aimed at, the illumination of the ceiling should be considerably more; whilst if indirect lighting is adopted and most of the light is deliberately concentrated on the ceiling, illuminations of 100 or more foot-candles are not unusual.

The Planning of Lighting Installations.

A word or two may be said here in regard to the planning of lighting installations to give an agreed illumination in foot-candles. The successive steps usually are: (1) the requisite illumination; (2) the type of fitting to be used; (3) the spacing and mounting height; and (4) the size of lamp. Agreement having been reached in (1) and (2) it is, of course, always possible to determine the conditions by first principles, i.e., by calculating the illumination yielded by a number of fittings spaced in various ways and adding the results together. In very exceptional and novel circumstances this may be the only really satisfactory way. But the process is laborious and involves a knowledge of the polar curve of light distribution of the fittings selected, and of the effect of reflected light from walls and ceilings.

A more usual plan, seeing that most modern installations consist of identical lighting units spaced symmetrically at regular intervals throughout the entire room, is to treat the installation as a whole, making use of formulae to determine the aggregate effect of all the units in one operation.

The basic formula applied for this purpose is:—

$$\text{Lamp Lumens Required per Lighting Unit} = \frac{\text{Foot-Candles} \times \text{Area per Unit in Sq. Ft.} \times \text{Depreciation Factor}}{\text{Co-efficient of Utilisation.}}$$

The application of this formula depends entirely on a knowledge of the "utilisation factor," that is, the proportion of the total flux of light (in lumens) furnished by the lamps installed which falls upon the working plane.

This factor depends upon: (1) the polar curve of the fitting selected; (2) the height of suspension; (3)

the dimensions of the room to be lighted; and (4) the nature of the walls and ceilings (whether dark, medium, or light in colour). The process of determining this factor is, therefore, rather complicated. It involves the use of a series of tables, such as those included in an admirable handbook issued by the E.L.M.A. Lighting Service Bureau.*

Careful study of the series of tables would enable the result of almost any combination of circumstances to be foretold. Fortunately, in the average factory the utilisation factor does not vary within very wide limits. Assuming that (1) lamps in fittings of good quality furnishing medium light distribution for direct lighting are adopted; (2) usual mounting heights of, say, 9 to 12 ft. are employed, and units spaced at distances equal to about $1\frac{1}{2}$ times their height and giving substantially uniform illumination; and (3) ordinary interiors with moderately light walls and ceilings exist, the utilisation factor will be found to lie in the neighbourhood of 0.5 to 0.6.

Leaving out of account for the moment the question of depreciation (i.e., assuming a depreciation factor of unity and inserting in the formula a value of, say, 0.55 for the utilisation factor), we readily obtain the lumens per lighting unit necessary to furnish the desired illumination. From tables available from any lamp-maker, the corresponding wattage of gas-filled electric lamps can be obtained, and from firms furnishing gas lamps the gas consumption corresponding to a certain mean spherical candle-power and flux in lumens should also be obtainable. The process can, in fact, be applied to gaslighting installations with little modification. In selecting a utilisation factor, when indirect lighting is substituted for direct lighting, the utilisation factor may be reduced by half, and for semi-indirect lighting an intermediate value adopted.

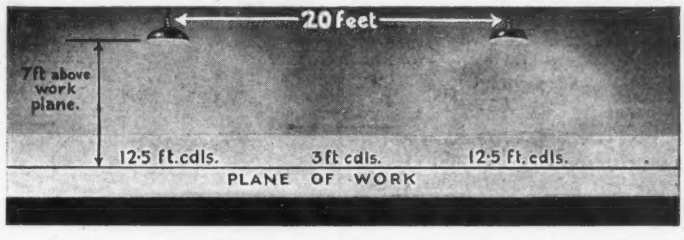
Inspection of the formula shows that, granting the above three consumptions, we arrive at practically the same simple rule suggested in our article last month—namely, that with average conditions of direct lighting an expenditure of 1 watt of electricity, or 1-100 cubic feet of gas, should result in an illumination of about 8 to 10 foot-candles.

Allowance for Depreciation.

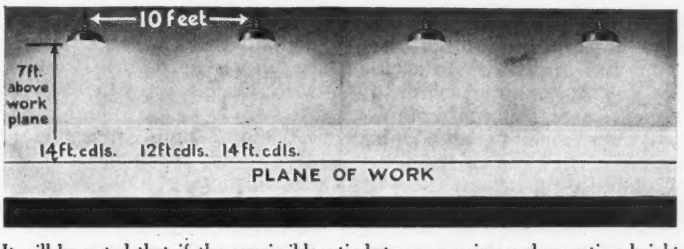
The above calculation, however, gives us only the initial illumination, i.e., when the lamps and fittings are new. It is usual to introduce into the formula a depreciation factor varying from 1.25 to 1.5 in order to allow for the inevitable loss in light through ageing of lamps, and deposits of dirt on lamps, fittings, and surroundings. Where much smoke, moisture, and dust exist the upper value (1.5) is none too high. On the other hand, in model installations, when lamps and fittings are regularly cleansed, and especially where the ventilation system provides the building with a continuous supply of dust-free air, the lower figure may prove a generous one.

Uniformity of Illumination.

Uniformity of illumination is primarily a matter of adopting a spacing for units corresponding with the polar curve of light distribution. The accompanying diagram shows what happens when lighting units are spaced too widely. Makers of lighting fittings should supply polar curves, accompanied by a statement in regard to the correct spacing. For average conditions of direct lighting satisfactory conditions are usually secured with forms of fittings intended to be spaced at a distance approximately $1\frac{1}{2}$ times their height above the working plane. In a well-designed installation the variation in illumination over the working area should not be more than 25 per cent., and will frequently be less.



The above units are spaced too far apart for their mounting height and furnish very uneven illumination. Working positions midway between units will be inadequately lighted and harsh shadows will result. The remedy is to mount the units higher, or, if this is impracticable, to space them closer as shown below.



It will be noted that if the permissible ratio between spacing and mounting height is not exceeded, uniform illumination will be produced. Note also the overlapping of light which serves to eliminate shadows as the units are brought closer together.

(Courtesy the E.L.M.A. Lighting Service Bureau.)

All this, it will be observed, relates to overhead general lighting. Problems involved in local lighting are reserved for a later article.

Rhenium—a Rare Metal

Rhenium or "Divi-Manganese" derives its name from the German Rhine. It has an atomic number (75), midway between those of tungsten and osmium, both of which have been used for lamp filaments. There has, therefore, been some speculation about its value to the lamp industry. Its melting point (3440° K + 60°) is lower than that of tungsten (3655° K + 40°), but its electron emission is considerably lower, and it volatilises less readily. It is also more resistant to the attacks of oxidising gases at high temperatures. These facts, coupled with the ductility of the metal seem to suggest possible value as a material for filaments. Until recently, however, it was certainly regarded as scarce. Though detected in many minerals the content was rarely more than 0.001 per cent. It has however been recently stated that means of obtaining it in moderate quantity have been developed.

* Illumination Design Data Handbook, No. 2b.: Issued by the E.L.M.A. Lighting Service Bureau, 2, Savoy Hill, London, E.C.

Lighting in Shops and Stores*

THE field covered by this title is so wide that one might easily spend an hour discussing any one section of it, such as the lighting of shop windows, the interior illumination of stores, and so on. For this reason I am anxious to limit the subject as much as possible, and it seems to me that the essential of shop lighting must be that directly, or indirectly, it contributes to the art of selling.

I, therefore, propose to consider the subject purely from the point of view of those forms of lighting which may help the primary object of the establishment of the shop, namely, the selling of goods.

Lighting may contribute to this end in various ways, of which the following are probably the most important:—

(a) By attracting from greater or less distances the attention of passers-by.
(b) By drawing attention to bargains available, and by emphasising the quality of goods.
(c) By creating a pleasant atmosphere and showing off goods to the best possible advantage.
(d) By combining with the last quality features of decorativeness and novelty that in themselves attract customers to the building.

I propose to deal with the different classes of lighting in the above order.

The two principal methods for attracting attention from a distance by light, are floodlighting and electric signs. Wherever a building has any claim to architectural design, and where any reasonable portion of the facade can be seen from a reasonable distance away, floodlighting presents the most dignified and effective form of treatment.

From the point of view of building design, it is of the greatest importance that the possibilites of floodlighting should be envisaged in the early stages.

The other method by which attention can be attracted from a distance is by the use of illuminated signs. There are many types of signs on the market, and the first consideration in selecting a sign for this purpose would seem to be that its day appearance is of no less importance than its night appearance.

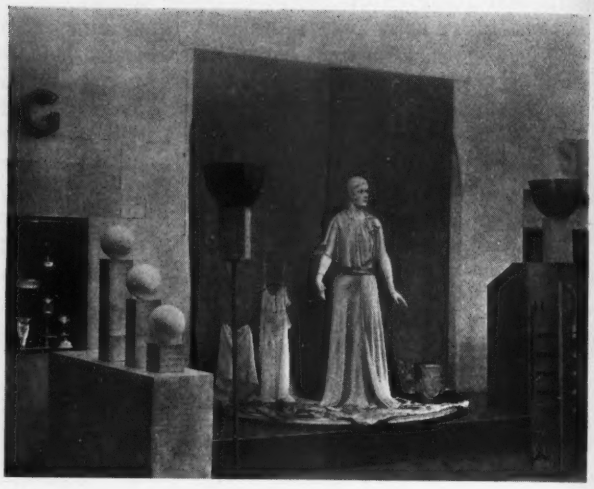
With regard to our second heading, namely, attracting attention to bargains available, and emphasising the quality of goods, it is well known that for many years the most popular and generally recommended type of window lighting has been by means of mirror glass reflectors placed immediately at the back of the window pelmet and punching the light more or less evenly over the whole of the window from front to back, and from top to bottom.

Shopkeepers nowadays, however, are demanding new methods and great developments in this direction may shortly be made.

Arcades and island windows are always a problem to the Illuminating Engineer, as there is difficulty in lighting a window in such a way that the illumination is actually effective when viewed from all sides.

My own opinion is that an island window should be lit, in principle, from the street frontage as, first, this is the direction towards which the main scheme of dressing is normally directed and, secondly, by the time the prospective customer has got round to the other side of it, the windows have already done half their job, namely, attracting the customers to look at them.

* Extracted from a talk given by Mr. R. O. Ackerley before an audience of Architects at the Elma Lighting Service Bureau in February, 1934.



Certain types of window lighting reflector on the market tend to concentrate a very high intensity of light on to a comparatively narrow area in the centre of the window. While this treatment may be suitable in a limited number of cases where the goods are of such a nature that they lend themselves to display in the centre of the window, and the centre only, as a general rule the window-dresser likes to have latitude to adjust the nature of his display without limitation as to the position in the window where his goods will show to advantage, and for this reason a type of reflector which distributes light evenly over the whole area is far more flexible than one of the more concentrating type.

As regards the use of colour in window lighting, colour should only be used subserviently to the main lighting, otherwise the goods themselves will suffer from colour distortion. Striking effects can, however, be made by concentrating the colour, either in one fixed batten, or changing by means of flashers or dimmers on to the background, while the goods in the foreground remain illuminated with white light.

We now turn to our next two headings which refer mainly to the interior of the shop, namely, creating a pleasant atmosphere, and showing goods off to the best advantage, and combining with the last quality, features of decorativeness and novelty that in themselves attract attention and cause talk.

The difficulty here is to obtain any really reliable data to indicate what effect a change in lighting system on any particular class of goods has on the sales.

Before leaving the subject of interior lighting of shops, however, there is one subsidiary form of lighting which is too important to pass over without reference. This is the question of the provision of adequate lighting in counter display cases, showcases, etc. Apart from the fact that such illumination tends to give life to the whole of the interior of the shop, it at the same time allows the interior showcases to take the place of additional windows in that it attracts the prospective purchaser's eye to all sorts of goods which he might otherwise have overlooked.

In most shop lighting installations the annual bill for current consumed is quite an appreciable item, and while we should be the last to suggest that money spent on illumination is not money profitably spent, it is obviously a bad investment to pay for illumination which is not actually reaching the areas you wish to illuminate.

TECHNICAL SECTION

COMPRISING

Transactions of The Illuminating Engineering Society and Special Articles

The Illuminating Engineering Society is not, as a body, responsible for the opinions expressed by individual authors or speakers.

The Illuminating Engineering Society

Notes on Recent Meetings and Events

A MEETING of the Illuminating Engineering Society took place in the Lecture Theatre of the E.L.M.A. Lighting Service Bureau (2, Savoy-hill, London, W.C.), on Tuesday, March 13. Members assembled for light refreshments at 6.30 p.m., and the Chair was taken by the President (Mr. C. W. SULLY) at 7 p.m.

The Minutes of the last meeting having been taken as read, the HON. SECRETARY read out the names of applicants for membership, which is appended. The names of those presented at the last meeting on February 20 (ILLUMINATING ENGINEER, March, 1934, p. 79) were read again, and these gentlemen were formally declared members of the Society.

The PRESIDENT then called upon MR. R. O. SUTHERLAND to present his paper on "The Aesthetic of Electric Lighting in Architecture." The paper, as the title suggests, dealt with many problems of interest alike to the architect and the illuminating engineer, and was illustrated by numerous lantern slides of modern lighting installations and also by models showing various visual phenomena.

In the subsequent discussion, DR. E. ENGLISH, MR. T. P. BENNETT, MR. WALDO MAITLAND, MR. R. H. HOLMES, MR. H. CHEVALIER, MR. J. H. BURMAN, MR. JUSTUS ECK, and MR. J. S. DOW took part.

After MR. SUTHERLAND had replied to the discussion and had been accorded a hearty vote of thanks for his paper, The PRESIDENT announced forthcoming events, which included a Special Meeting in Manchester on March 15 and a Visit to Messrs. Glyn, Mills and Co., Ltd., and Unilever House in London on March 22.

Further reference to these events and to Mr. Sutherland's paper and the ensuing discussion will be made in our next issues.

Applicants for Membership.

Corporate Members:—

Burman, J. H. .....Public Lighting Inspector, 13, Churchill Road, Willesden Green, LONDON, N.W.2.

Davies, M. Tudor .....The Electric Lamp Manufacturers' Association, 25, Bedford Square, LONDON, W.C.1.

Stacey, G. .....The Benjamin Electric, Ltd., Tariff Road, Tottenham, LONDON, N.17.

Wood, A. V. .....908, Chester Road, Erdington, BIRMINGHAM.

Country Members:—

Baxter, W. M. .....55, Pershore Street, BIRMINGHAM.

Bell, R. D. .....The Old School House, Mere, CHESHIRE.

Mortimer, G. .....The British General Electric Co., Ltd., P.O. Box 2406, Johannesburg, SOUTH AFRICA.

Smith, K. W. .....The General Electric Co., Ltd., Victoria Bridge, MANCHESTER.

Affiliated Students:—

Anderson, N. D. .....The General Electric Co., Ltd., Magnet House, Kingsway, LONDON, W.C.2.

Cole, A. P. .....Holophane, Ltd., Elverton Street, Vincent Square, LONDON, S.W.1.

Holman, R. W. .....102, Hillside, Moulescoombe, BRIGHTON.

Kuvanonda, P. .....Dalton Hall, Victoria Park, MANCHESTER.

Scott, G. P. .....General Electric Co., Ltd., 89, Northover, Downham Estate, Grove Park, KENT.

Forthcoming Events

The **Next Meeting** of the Society will be held in the Lecture Theatre of the Institution of Mechanical Engineers, Storey's Gate, Westminster, S.W.1, on **Tuesday, April 10th,** when a paper on **"The Artificial Lighting of Gardens"** will be read by MR. JUSTUS ECK. **6.30 p.m.**

The **Annual General Meeting** will take place on **Tuesday, May 8th,** when the Annual Report of the Council will be presented and the usual Formal Business transacted. We understand that **an address reviewing progress in illumination in the United States** will then be delivered by MR. SAMUEL G. HIBBEN (Director of Lighting for the Westinghouse Company, New York City.) **6.30 p.m.**

Heterochromatic Photometry

with Particular Reference to the Photometry of Luminous Discharge Tubes*

By H. Buckley

(of the National Physical Laboratory)

I. INTRODUCTION.

For the measurement of coloured light there are three general methods of heterochromatic photometry possible These are:—

(1) By " direct comparison " using a photometer of the equality of brightness or of the contrast type. The comparison is very difficult and many observers are required before its results can be regarded as having any significance.

(2) By " flicker " comparison using a flicker photometer. The comparison is fairly easy and the results for the observers reproducible and directly referable to those which would be obtained with the so-called standard or average observer.

(3) By calculation based on the distribution of energy in the spectra of the light sources and the visibility curve which has been internationally agreed as representing the luminosity properties of the average eye. This method is simple in theory, but tedious in practice, besides demanding an experimental technique in spectrophotometry which is not very common.

Historically the methods have been studied most intensively in the order in which they are given above.

II. EQUALITY OF BRIGHTNESS PHOTOMETRY.

Early experience with the equality of brightness method led to the recognition of three main troubles with it. They are that the concept of equality of brightness of two juxtaposed coloured surfaces is different:—

(1) for different observers;
(2) for different field sizes used in the comparison;
(3) for different brightness levels used in the comparison.

The difference due to different observers is inherent in the method. Observers' visual characteristics are different, and hence arose the practice of referring photometric measurements on colour differences to larger and larger groups of individuals as the colour differences became larger, in the hope that the average of the results would approximate to that of the average undefined and unknown observer.

For small colour differences the final results are approximately independent of the selection of the observers and of the conditions of field size and brightness used. For larger colour differences the results become erratically dependent on the undefined choice of observer and systematically dependent on the field size and brightness conditions used in the measurements. In fact, for large colour differences many observers fail to make consistent measurements at all, and those who do, very often make a consistent set of measurements on one occasion, followed by equally consistent but quite different sets of measurements on other occasions. In order to obtain each observer's result it is necessary to make observations over periods of time which will ensure that any memory of one determination is wiped out before the next is made, i.e., to make each determination an independent one.

The differences due to the different brightness levels at which the observations are carried out have been found to be systematic in as much as at low brightnesses the eye gives greater weight to the shorter wave-length light. This is the well-known Purkinje effect, which can be seen when a spectrum is gradually reduced in brightness, the brightest portion of the spectrum moves towards the blue end. The differences due to the field size are also systematic, and it has been found that as the field size is increased, the eye gives greater weight to the shorter wave-lengths. This is the well-known yellow spot effect. Early work showed that the Purkinje effect was smaller the smaller the field size, and established that for vision confined to the fovea, most observers do not show any Purkinje effect.

These two systematic effects receive qualitative explanation from the known variation in properties of the retina over its area. The visual mechanism of the retina consists of rods and cones, the relative distribution of which varies from the fovea towards the periphery. In addition, the macula lutea, a small area surrounding and including the smaller fovea, is associated with a yellow pigment. The cones are more red sensitive than the rods. At the fovea there are no rods which increase in relative numbers towards the periphery of the retina. These are responsible for vision at low intensities. The absence of the Purkinje effect at the fovea is explained by the absence of rods. The yellow spot effect is explained by the absorption of the yellow pigment of the macula lutea and by the increasing part which the rods play in vision as the visual field is extended.

III. FLICKER PHOTOMETRY.

Early in the present century the second method, viz., the flicker photometer, received much attention. The flicker photometer owes its applicability to heterochromatic photometry to the fact that colour flicker disappears at a lower speed than brightness flicker. In consequence, it is possible to alternate the photometric fields which are being compared at a speed higher than that necessary to cause colour flicker to disappear, but yet low enough to leave a brightness flicker. This brightness flicker then disappears when the brightnesses of the two photometric fields bear a certain relation to each other. If the two fields have the same colour, the brightnesses for no flicker are the same as those which are equal as judged by the equality of brightness photometer. If the two fields are of different colours, the relative brightness may or may not be the same as those observed as equal by the equality of brightness photometer. That the two photometric methods should disagree is not surprising when it is remembered that the equality of brightness method does not give a result independent of the conditions under which the measurement is made.

A systematic investigation of the flicker photometer was made by Dow (1) in 1909. He investigated the de-

* Paper read at the meeting of the Illuminating Engineering Society, held at the Institution of Mechanical Engineers, Storey's Gate, St. James's Park, London, S.W.1, at 6.30 p.m., on Tuesday, February 20, 1934.

pendence of the result given by the flicker photometer with variation in field size and brightness. His results showed that the flicker photometer showed less Purkinje effect and yellow spot effect than did the equality of brightness photometer.

With the equality of brightness photometer the Purkinje effect is absent or very small for small fields, and the yellow spot effect is smaller the higher the field brightness. Consequently, for high brightness and small field size the differences between the methods may be small, and it may be possible that with specified field brightness and size the two methods will give the same results.

With this idea in mind Ives [2] in 1912 investigated these phenomena in detail with the equality of brightness photometer and flicker photometer. His method consisted in determining the luminosity of the spectrum by each method. That is, he compared the luminosity of successive small portions of the spectrum with the white light from a carbon lamp. For the equality of brightness method he confirmed the results of previous investigations that the Purkinje effect is less the smaller the field size, that the effect of field size is less the higher the brightness, and that all the marked changes in the luminosity curves he obtained occurred at illuminations of less than 7 metre-candles.

It should be noted, however, that as regards the effect of field size his first experiments showed that at all illuminations decrease in field size reduced the yellow spot effect, but later experiments gave substantially no yellow spot effect at high illuminations. He concluded, however, that at high illuminations the yellow spot effect was small or absent whatever the field size.

As regards the flicker method, he showed that (a) the precision was high and unaffected by psychological disturbances such as affect the equality of brightness method; (b) the results approximate asymptotically to those of the equality of brightness method with increase of illumination and reduction of field size; (c) the agreement between the two methods is satisfactory if the illumination of the photometer screen is 25 metre-candles or more and the field size does not subtend an angle of more than 3°; (d) a steady surrounding background brightness increases the comfort of observation without affecting the results.

On the basis of these results Ives laid down the physiological conditions for the use of the flicker photometer as follows:—

Field size	2° diameter
Field illumination	25 m.c. on a white surface
Field surround	25° diameter of approximately the same brightness as the 2° field.

He later recommended that all precision heterochromatic photometry should be carried out with the small 2° field at an illumination of 25 m.c., preferably with the flicker photometer.

Ives also determined the luminosity curves of the spectrum for eighteen observers by means of the flicker method. From these the relative visibility curve of the average eye was determined—i.e., the relative luminous effect of a unit of radiant energy at each portion of the spectrum.

In addition to showing how the flicker photometer could be used to obtain true luminosities, he also showed that the results of flicker photometer measurements conformed to the requirements of a photometric scale—i.e., things which are equal to the same are equal to each other, and that the whole is equal to the sum of its parts.

The flicker photometer by itself gives no indication of what the result would be supposing it were used by an observer possessing what we may call the average or standard eye. Ives then devised a method of classifying observers by which the results which would be obtained by the average eye can be deduced. The method consisted in determining the value which each observer obtained for the ratio of the transmisisons of two solutions; one yellow, transmitting the yellow and red end of the spectrum, and the other blue, transmitting mainly the green and blue end of the spectrum. The concentrations of these solutions were adjusted so that the average of a large number of observers was 1.0 for this ratio while individuals varied mainly from 0.9 to 1.10, with a relatively small number outside these limits. The ratio of each observer is usually referred to as the Y/B ratio, that of the average eye being 1.0.

Crittenden and Richtmyer [3] investigated 114 observers by this method and adjusted Ives' values of the concentrations so that the average ratio of the 114 observers, all of whom were regarded as possessing normal vision, was unity. These revised solutions consist of ten millimetre layers of solutions contained in clear glass cells. The yellow solution consists of 72 grams of pure potassium bichromate per litre of solution and the blue solution 57 grams of pure copper sulphate per litre of solution.

It has been found by experience that the plot of photometric measurements on many kinds of colour difference exhibits a straight line relation between the Y/B ratios of the observers and their individual results, so that the photometric result for the average eye, i.e., Y/B ratio equal to unity, can be obtained by interpolation from the results of a limited number of observers' measurements.

The flicker photometer in combination with the use of the yellow and blue solutions thus, according to Ives, provided a complete solution of the heterochromatic photometry problem. It was relatively simple to use and gave results which were as near to those given by the equality of brightness method as the inherent difficulties of that method permitted

IV. PHOTOMETRY BY CALCULATION.

The third method has only been considered as a feasible method of photometry relatively recently. Others besides Ives determined the visibility curve of the eye by various methods, including the flicker method and the step by step equality of brightness method in which each portion of the spectrum is compared with a neighbouring portion differing only slightly in colour. The field sizes and brightnesses were usually different in these determinations. The most recent determination, that by Tyndall and Gibson [4], was carried out by the step by step equality of brightness method on fifty observers. It was concluded from the results that the visibility curve obtained by the equality of brightness method was identical within the limits of experimental errors with that obtained by the flicker method if the field size and brightness were those specified for the agreement of the two methods, viz., small field size and high brightness. The differences between Tyndall and Gibson's determination and those of Coblentz and Emerson, of Nutting and of Hyde, Forsythe, and Cady, were in general such as one would expect from the known effects of variation in field size and brightness.

Thus, with the establishment of an average visibility curve independent of the method of determination, subject only to the field size and brightness conditions, the visibility curve of the average eye was raised from the status of mere information about the eye, to the status of definite numerical values, which, in association with spectral energy distribution data, could form the basis of photometric calculations.

When the values of Tyndall and Gibson, very slightly modified, were adopted by the International Commission on Illumination, at Geneva, in 1924, photometrists had at their disposal three methods of photometry, equality of brightness, flicker, and calculation, which the best available knowledge suggested should all give the same results when applied to the problems of photometry. It only remained to test them.

The first international test of the methods took place as a result of the decision of the representatives of the four national laboratories at the meeting of the I.C.I. at Bellagio in 1927, to determine the transmissions of blue glasses by the three methods. The blue glasses were such that they would change the colour of the

light from a carbon lamp to colour match that from a vacuum tungsten lamp. It is sufficient to state here that as regards the Bureau of Standards and the National Physical Laboratory, for whom the data by the flicker and calculation methods are most complete, each of these laboratories found the flicker method to agree with that of calculation to within 0.3 per cent. and that with the equality of brightness method at a lower illumination than was used in the flicker method and with a larger field, all the participating laboratories obtained results higher than those given by calculation (5). Qualitatively the higher values for this method are what one would expect from the deviation from the field size and brightness conditions specified by Ives—the blue end of the spectrum received greater weight.

It is the purpose of this paper to present data showing how far the methods agree for the much larger colour differences which are met in connection with coloured glasses and with the gaseous discharge tubes which photometrists are now being asked to measure.

V. COMPARISON OF FLICKER PHOTOMETER METHOD WITH CALCULATION METHOD.

For the purpose of comparing the flicker photometer method with the calculation method, a number of coloured glass filters were used. Most of these were optically worked so that the surfaces were plane and parallel, and the variations in thickness over the surface did not usually exceed a hundredth of a millimetre.

Spectrophotometric measurements of the transmissions of the filters were made throughout the spectrum by means of the spectrophotometer, described by Buckley and Brookes (6). The temperature of the air near the glasses was observed when glasses whose transmission varies with temperature were being measured. The temperatures were always within 2° of 20° C., the temperature which was adopted as the standard temperature both for spectrophotometric and flicker photometer measurements.

The integral transmission ratios of the filters were then calculated for radiation of colour temperature, 2400° K, using the tables prepared by Skogland (7). The limiting effective wave-length of each filter for radiation of colour temperature, 2400° K, was either calculated or determined experimentally. The limiting effective wave-length is very nearly the same as the wave-length passing through the centre of gravity of the luminosity curve of the radiation which is transmitted by the filter, i.e., the spectral centroid of the transmitted radiation.

Particulars of the filters are set out in Table I., which gives (1) the number of the filter; (2) the colour; (3) the limiting effective wave-length; (4) the calculated transmission ratio T_c of the filter for light of colour temperature 2360° K; (5) the transmission ratio (T_F) observed on the flicker photometer; (6) the ratio T_F/T_c. Except for filters A and F, which were of flashed glass, the filters were body coloured. The spectrophotometric transmission values of the filters throughout the spectrum are shown in figs. 1 and 2.

It is considered that the integral transmission ratios given in Table I. are correct to better than 2 per cent. for glasses having a high transmission over considerable portions of the spectrum. For the red glasses

TABLE I.

No. of filter	Colour of filter	Effective wavelength	Calculated transmission T_c	Flicker transmission T_F	$\frac{T_F}{T_c}$
CF 43	Dark Red ...	0.650μ	5.67%	5.61%	0.990
CF 14	,, ...	0.643	9.56	9.30	0.973
CF 42	,, ...	0.642	10.10	10.26	1.016
CF 44	Light Red ...	0.638	13.24	13.30	1.005
CF 13	,, ...	0.636	14.85	14.50	0.976
F	,, ...	0.629	9.25	9.30	1.006
A	,, ...	0.617	14.20	14.16	0.997
CF 3	Dark Orange	0.603	42.3	42.6	1.008
CF 4	Light Orange	0.595	53.5	54.3	1.016
CF 11	Ortho Green	0.573	73.2	73.0	0.996
CF 21	Pale Blue .....,	0.561	20.0	19.9	0.995
CF 10	Daylight	0.556	26.8	26.1	0.974
CF 9	Cobalt Blue ...	0.553	7.42	7.28	0.981
CF 5	Sap Green ...	0.551	11.18	10.92	0.976
505 L	Blue Green ...	0.541	16.85	16.15	0.958
505 D	,, ,,	0.535	10.95	10.35	0.945

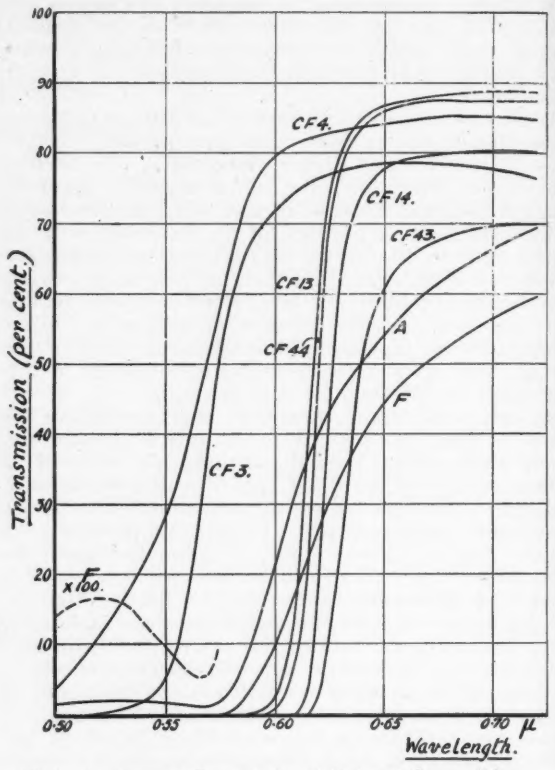


Figure 1. Spectral Transmission of Red and Orange Filters.

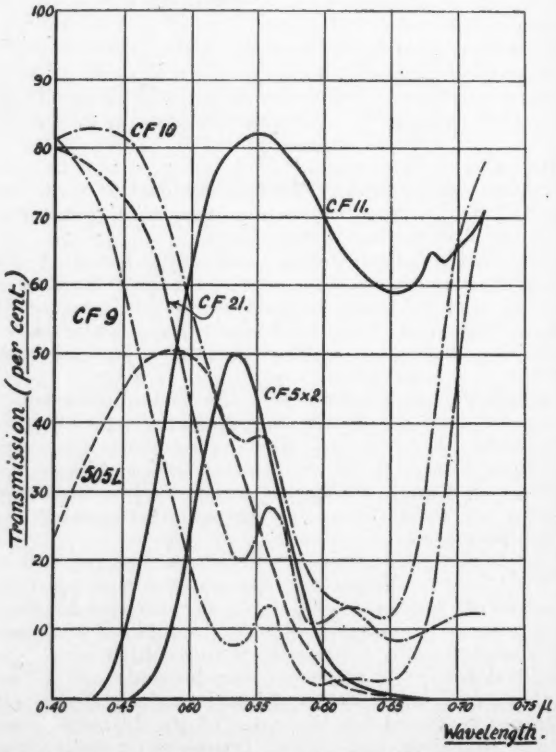


Figure 2. Spectral Transmission of Green and Blue Green Filters.

which have very steep transmission curves, and which even when optically worked are not quite uniform in transmission, the error may be a little more.

The flicker photometer used for the determination of the transmissions of the filters was that described by Guild (8). It fulfilled the conditions as regards field size and field environment as specified by Ives and was operated so that the illumination on the comparison screen was always 25 metre-candles. The comparison lamp was a uniplanar 75 watt vacuum lamp operated at a colour temperature of about 2250°K. The lamp on the test side was a 500 watt uniplanar gasfilled projection lamp operated at a colour temperature of 2400°K. The determination of the transmission of a filter consisted in the setting of the 500 watt lamp to balance the illumination from the comparison lamp with and without the colour filter interposed. Thus the full colour difference was effective in all measurements when the colour filter was used. The speed of the photometer was left to the choice of the observers, who were advised to operate it at the slowest speed at which they were satisfied. Actually the speeds used varied very considerably. Fifteen filters were investigated, and the transmission of each was determined either two or three times by means of the flicker photometer.

The number of observers used in the measurements was fifteen, of which nine were used for the measurements on the lighter filters and thirteen for measurements on the extreme red and blue green filters.

In order to obtain the transmission ratio of each filter for the average observer the results were plotted against the Y/B ratios of the observers, and the best straight line which could be drawn to fit the results was put on the graph, and the value corresponding to a Y/B ratio of unity read off from the graph.

Four examples of the results are shown in fig. 3, in which it is seen that the position of the straight

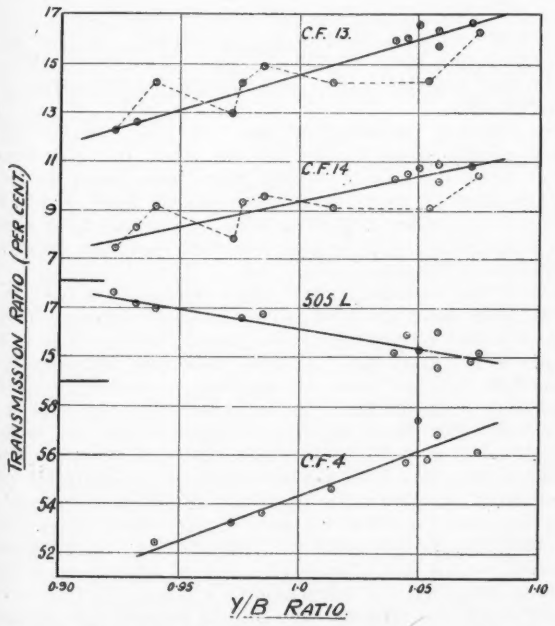


Figure 3. Variation of Transmission with Y/B Ratio of Observer.

line is quite definite. A comparison of the distribution of the individual observations with respect to the best straight line through the observations shows a remarkable similarity in the case of the two red filters CF.13 and CF.14 shown in fig. 3. The flicker criterion is thus a quite definite and repeatable criterion for each observer. It is obvious, also, for these filters that a different choice of observers would have given a somewhat different result. Thus, if the two end observers, together with the four whose observations fall below the line, had been chosen, the results for a Y/B ratio of unity would have been about 3 per cent. lower than those actually deduced from the results of the fifteen observers. There appears to be a greater spread in the results for the red filters than in those for the blue and blue green glasses as represented in fig. 3 by filter 505L. The ratio of the integral transmission as found by the flicker photometer to that found by calculation was then determined for each filter. The results are shown in the last column of Table I. These results are graphed in fig. 4 with respect to the limiting effective wavelength. From the figure it is apparent that except towards the blue end of the spectrum the values obtained by means of the flicker photometer are in excellent agreement with those derived by calculation. Even towards the blue end the differences are not very much more than the possible errors of the observations and calculations.

These results may be compared with those given by Crittenden and Taylor (9) for a series of filters which were measured by three laboratories in America in 1928. These are illustrated in fig. 4, in which the

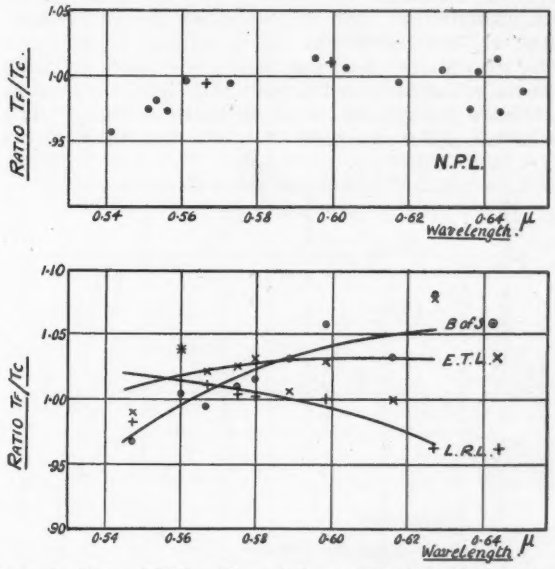


Figure 4. Ratio of Flicker Transmissions to Calculated Transmissions.

abscissae are spectral centroids which correspond closely with effective wavelengths. Those carried out at the Bureau of Standards are the means of the results obtained by using ten and thirty-three observers, and were made in the same way and with the same field brightness as those made at the National Physical Laboratory. Those made by the Lighting Research Laboratories of the General Electric Company, Nela Park, were by nine observers, but at much higher illuminations than those used at the Bureau of Standards and the National Physical Laboratory.

The authors concluded that the results taken as a whole showed that any systematic difference between the results of measurements made by the flicker photometer and those obtained by calculation from the standard visibility data was small.

The results of the work carried out at the National Physical Laboratory on filters covering a somewhat wider range of the spectrum, strengthens that conclusion as regards the portion of the spectrum from 0.56μ to 0.65μ. The results on the blue green filters, however, seem to show definitely that below 0.56μ the results of the flicker photometer are increasingly systematically lower than those given in calculation.* At the same time, it must be concluded that for measurements of the type considered, the flicker photometer, with very little trouble, gives results

* The points at 0.566μ and 0.599μ refer to the blue and yellow solutions used in determining the Y/B ratios.

which are sufficiently accurate for most purposes for which these coloured lights are used. The results may not correspond exactly to those which would be obtained by the average eye, but they do correspond to those obtained by an eye which, compared with the possible variations, is not very different from the normal eye.

VI. COMPARISON OF EQUALITY OF BRIGHTNESS METHOD WITH CALCULATION METHOD.

At the same time that the Bureau of Standards made the flicker and spectrophotometric measurements referred to in the previous section, an attempt was made to determine the transmission ratios of the glasses by equality of brightness methods. For these measurements three photometers were used.

(1) Lummer Brodhun photometer oval field 8° x 11°.

(2) Weber photometer circular field 6.5°.

(3) Martens polarisation photometer, small field:

The measurements were taken with and without the filters inserted so that in each case the full colour difference was measured.

The illuminations on the photometer were from 30 to 70 metre-candles on the Lummer Brodhun and on the Weber photometer 18 to 35 metre-candles. The results are given in fig. 5, in which the ratios of the

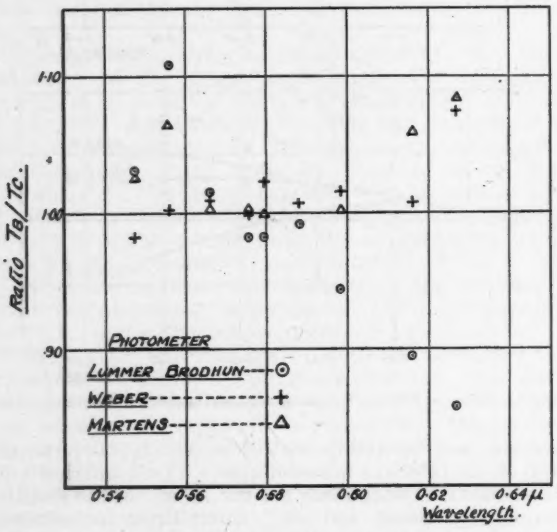


Figure 5. Ratio of Observed Transmissions (Equality of Brightness) to Calculated Transmissions. B of S.

observed transmission to the calculated transmissions are plotted against spectral centroids. In each case the plotted value is that obtained for a Y/B ratio of unity. The difference between the results obtained by the Lummer Brodhun and the Weber photometers are very large, and the general trend of the results is different in the two cases. The average of the results by ten observers on each of the three photometers gave values which did not differ by more than 2 per cent. from the calculated values, except in one case, when the difference was 6 per cent.

Dudding, Winch, and Cooper [10], in 1931, found for six very experienced observers of unknown characteristics, except that they were regarded as normal, that the results of measurements made with the full field Lummer Brodhun photometer on colour-sprayed lamps were in good agreement with those obtained by calculation by spectrophotometric means.

A few measurements of this type were made at the National Physical Laboratory, but a small 2° field was used for the measurements. The flicker photometer was used with the rotating vane stationary and the set-up in all other respects identical with that used in making the flicker measurements reported in the previous section. The results, however, were disappointing.

The observers found it very difficult to decide on what was a photometric match. Actually the values found for the ratios were in all cases higher than the calculated values. Only for two glasses was the result in approximate agreement with the calculated value, e.g., a blue green filter (505L) and a light blue filter (CF.21). The average value of the ratios for the eight glasses was 1.075, and, apart from the two filters mentioned, varied in an unsystematic manner with effective wavelength from 1.06 (CF.4, and A), to 1.18 for red filter F.

It was noticed in the use of these glasses for the determination of the transmissions of orange railway signal lenses that the results obtained when CF.4 was used were not quite in agreement with those obtained when CF.3 was used. The photometer was of the Lummer Brodhun type, with large field, and CF.4 gave a good colour match with the lens, whereas CF.3 did not. If the comparison were made with a 2° field, the value of the transmission of the lens was practically independent of which of the two filters was used, that obtained with filter CF.4 being the same in each case.

A few experiments were made by comparing the transmissions of the pairs of similar glasses, CF4/CF3, A/F, CF13/CF14, and 505D/505L. In each case the numerator is a filter whose effective wavelength is shorter (bluer) than the filter represented by a denominator. The illumination on the photometer screen was 25 metre-candles, which is effectively about 15 metre-candles, if the transmissions of the optical parts of the photometer are considered. Except for CF13/CF14, the value of the ratio was found to depend on the field size used, and was larger for the large field than for the small 2° field. For the deep red filters, CF.13/CF.14 there appeared to be no change. The direction of the change was in each case to weight the blue end of the spectrum, i.e., in the direction indicated by the yellow spot effect. The amount of the change varied considerably for different individuals.

No detailed investigation has yet been made, but these results seem to indicate an effect of field size at a brightness level which was considered to be higher than those at which the yellow spot effect is active. A similar dependence of results on field size has been met in the measurement of mercury vapour luminous discharge tubes.

Since the visibility data were determined for the small field, we must take as correct those values which are obtained by means of the small field until it has been shown that the visibility data are not correct. This has not yet been shown, nor is it anticipated that they will be found to be incorrect. The fact is, however, that the visibility data have not yet been subjected to a test which would find out if they were correct or not. The experiments of the Bureau of Standards, in which the three photometers were used, if they can be regarded as definite, show that the average results obtained by means of two large field and one small field photometer are in agreement with results obtained by calculation, whereas if the visibility data are correct, we should expect the calculated results to agree with small field results only. With this object in view, the experiments with the full colour difference at the National Physical Laboratory were carried out with the small field size, but the results are not regarded as being definite enough for any conclusions to be drawn.

The experiments in which the transmission ratios of somewhat similar glasses are compared by means of the equality of brightness method using the large and the small field may afford a test of the data. It is hoped that it will be possible to continue these experiments.

(To be continued.)

A Method of Estimating the Proportion of Red Light Emitted by a Source, with Particular Reference to Gas Discharge Lamps

By G. T. Winch, A.M.I.E.E., and E. H. Palmer, B.Sc.

(Communication from the Staff of the Research Laboratories of the General Electric Company, Ltd., Wembley, England.)

THE introduction of the high-pressure mercury discharge lamp has revived interest in the influence of the addition of elements such as cadmium and zinc on the colour of the light emitted.

These elements were used in low-pressure mercury tubes as far back as 1902, and therefore in the early stages of the development of the modern high-pressure lamps the effect of the introduction of these elements was again investigated.

It became necessary to make quantitative measurements of the influence of these additives on the colour of the light, and the following is a description of a method which has been found practicable.

The underlying principle is to express the amount of light which is transmitted by a certain filter as a percentage of the total light given by the source. This principle can be readily applied to estimate the proportion of red light (as defined by the filter to be used with the discharge lamp) emitted by sources whose spectral energy distribution is known by integrating throughout the spectrum (1) the product of the transmission of the filter, the energy radiated by the source, and the relative luminosity data; and (2) the product of the energy radiated by the source and the relative luminosity data.

The " red ratio " for the source is the ratio of (1) to (2). This has been done for daylight and tungsten radiation, and is shown graphically in Figures 3 and 4 respectively, where curves A indicate the energy distribution, curves B the luminosity of the radiation, and curves C the luminosity of radiation transmitted by the Wratten filter No. 25. Clearly, the areas under the final curves C are proportional to the light which would be transmitted by filter No. 25, and the areas under curves B are proportional to the total light emitted. The " red ratio " is therefore the area under curve C expressed as a percentage of the area under curve B. This can be shown in the following way:—

$$\text{" Red ratio "} = \frac{\int_o^a T_\lambda \, E_\lambda \, K_\lambda \, d\lambda}{\int_o^a E_\lambda \, K_\lambda \, d\lambda} \times 100$$

Where T_λ is the transmission of the filter at wavelength λ E_λ is the energy emitted by the source at wavelength λ and K_λ the relative luminosity of energy of wavelength λ. The particular problem before us, however, was to measure the " red ratio " of a series of high pressure mercury lamps to which different proportions of the elements above mentioned had been added.

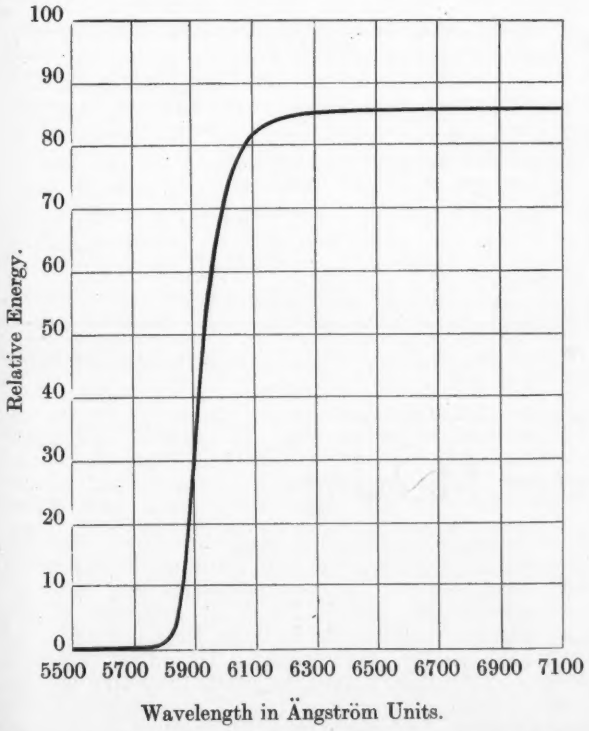


Figure 1. Spectral Transmission Curve of Wratten Filter No. 25 for Equal Energy.

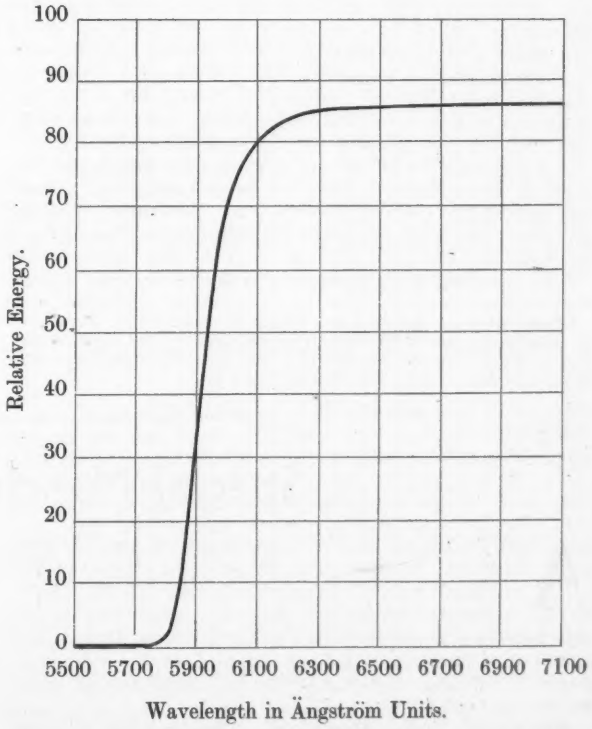


Figure 2. Spectral Transmission Curve of Wratten Filter No. 24 for Equal Energy.

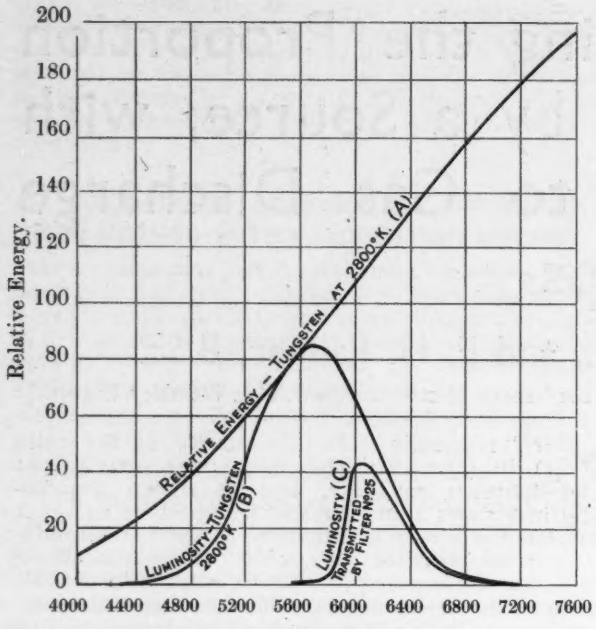


Figure 3. Spectral Energy and Luminosity Curves for Tungsten at 2800° k.

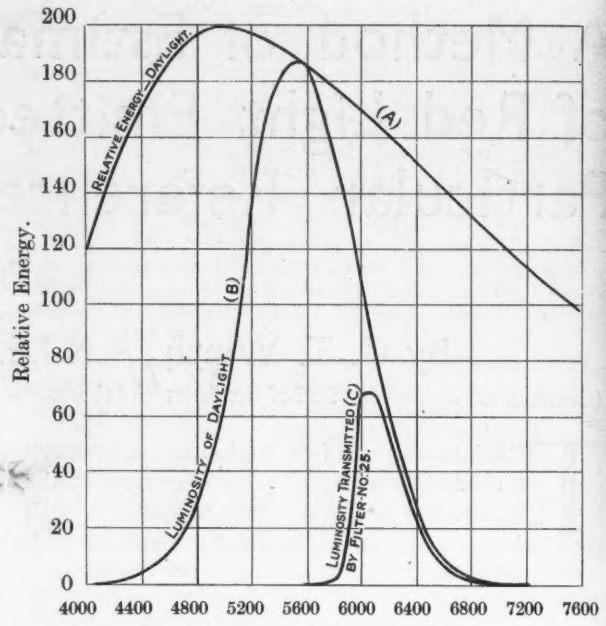


Figure 4. Spectral Energy and Luminosity Curves for Daylight.

In these cases it is easier to apply a modified experimental method, in which it is not necessary to determine the spectral energy distribution of the source.

The total lumens of the lamps are measured in the usual manner by operating them in a photometric integrator and making visual balances with a Lummer Brodhun photometer head on a calibrated photometer bench. Colour difference was reduced to a minimum by the insertion of a calibrated* blue colour filter between the comparison lamp and the photometer head. Having measured the total lumens of the lamp, the blue filter is removed and a similarly calibrated red filter, No. 24, inserted in its place. Also another suitably chosen red filter, No. 25, is inserted between the photometer head and the diffusing window of the integrator. The two sides of the photometric field are again closely similar in colour so that no difficulty is experienced in balancing the photometer. Providing the transmission factor of the red filter for the tungsten radiation of the comparison lamp is known, the lumens transmitted by the red filter, No. 25, on the integrator side of the photometer head can be readily determined. This value expressed as a percentage of the total lumens is the " red ratio " which is simply the percentage of the total light transmitted by filter No. 25.

The spectral transmission curves of the red filters used for this purpose are shown in Figures 1 and 2. The reason that different filters were used on the two sides of the photometer head was that Nos. 24 and 25 were available, and No. 24 had already been calibrated. As will be seen these two filters have similar spectral transmission curves and are therefore suitable for this purpose, but obviously it would be equally satisfactory, and in some cases preferable to use two identical filters.

† Table I shows the results of some measurements of the " red ratio " of high pressure mercury lamps with different proportions of colour correcting elements, together with the estimated values for daylight and tungsten radiation for purposes of comparison.

TABLE I.

	% Red Light or Red Ratio	Initial Luminous Efficiency as a Percentage of that of the High Pressure Mercury Lamp.
High pressure mercury lamp (400 w.)	1.0	100%
" " " " with little Cd. & Zn.	1.5	95%
" " " " with more	2.5	75%
" " " " " much	4.5	60%
Daylight	15.0	—
Incandescent filament tungsten lamp	27.0	—

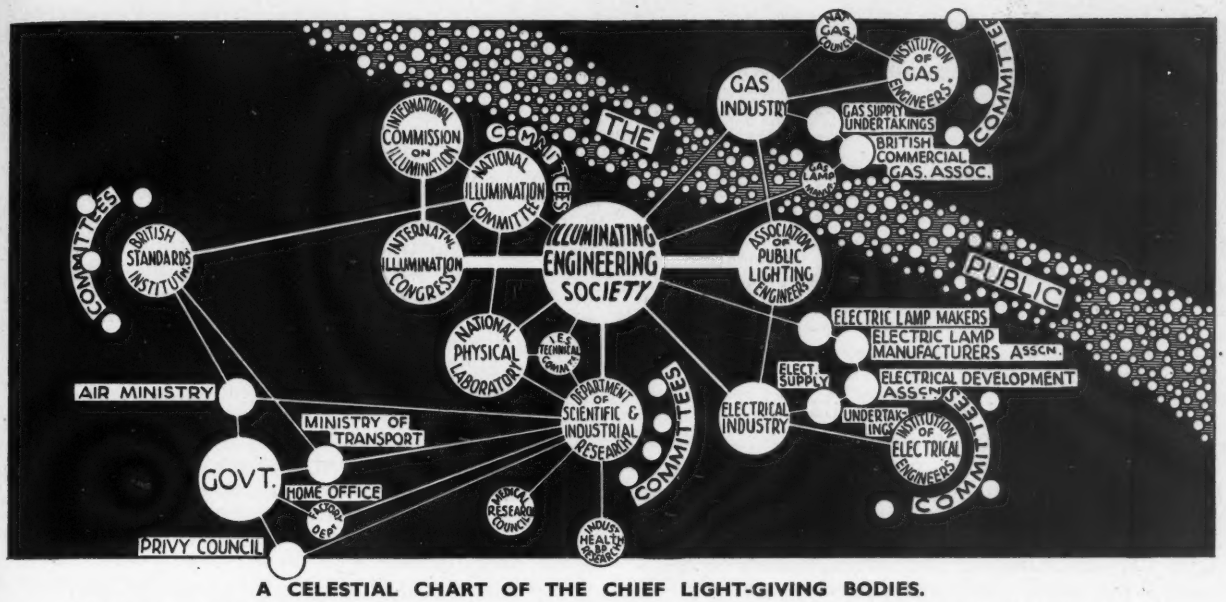
* Calibrated by method described by Buckley in his paper on Heterochromatic Photometry read before the Illuminating Engineering Society on March 13, 1934 (ILLUMINATING ENGINEER, April and May, 1934).

† Paper read March 7, 1934, by J. W. Ryde, before the Royal Society of Arts.

Special Manchester Meeting

A SPECIAL MEETING, arranged by the Illuminating Engineering Society in the Lecture Theatre in the College of Technology, Manchester, on March 15, was undoubtedly the most successful yet held in the North-West Area. The meeting attracted much local interest, and it was early evident that the resources of the hall would be strained to the utmost.

Mr. C. W. Sully (President), who took the chair at 7.15 p.m., delivered a modified version of the address delivered the previous month in Birmingham (see pp. 125-128), after which a really excellent show of exhibits, illustrating progress in illuminating engineering, was staged. A representative gas exhibit, assembled by Mr. Holton, the Chief Engineer of the Manchester Corporation D Gas Dept., was ably explained by Mr. Mainwaring. The other exhibits, sixteen in number, included electric discharge lamps, novel fittings, and various types of photometers. We mean to give a fuller account of the meeting in our next number. Meantime, we hope that the signal success of this meeting will lead to its repetition in other cities.



A CELESTIAL CHART OF THE CHIEF LIGHT-GIVING BODIES.

Readers may be interested to hear that the idea of such a chart was originally suggested by Mr. J. S. Dow in order to illustrate Mr. Sully's address, which follows; he is much indebted to Mr. G. H. Wilson for giving form to the suggestion and to his colleague, Mr. Downing, whose draughtsmanship evolved the above final design.

Artificial Lighting:

A Vista of The Future*

By C. W. SULLY

(President of The Illuminating Engineering Society)

INTRODUCTORY.

ON an occasion such as this, when the public is offered a unique opportunity of studying British industries, it is surely not inappropriate to devote a short time to a survey of what is really one of our greatest national industries—the production of artificial light.

In attempting such a survey there is sometimes a tendency to linger over reminiscences. I am, however, more disposed to examine the present and to attempt some forecast of the future. Therefore my introductory remarks on the progress of the art of lighting up to its present stage will be brief.

Illumination, indeed, has made progress—certainly greater progress during the past fifty years than in the many centuries that preceded them. Yet, compared with some of the newest adjuncts of civilisation, its rate of progress appears slow. Transport during the last century has been successively transformed by the advent of the steam engine, the motor car, and the aeroplane. During the same period, science has furnished us with new means of producing artificial light. Light, to-day, is far more abundant and less costly than a generation ago. Yet until recently its application has remained in substance the same, and there has been no such revolutionary advance.

In this respect, however, light resembles other primary and fundamental requirements of mankind, which usually have progressed more slowly than less essential requirements—contrast, for example, the development in agriculture with such less fundamental requirements as transport, communication by letter-writing, telegraphy, or telephony.

* Address delivered at the Special Conference at the British Industries Fair, Castle Bromwich, Birmingham, at 3 p.m., on Thursday, February 22, 1934.

THE MOTOR-CAR HEADLIGHT.

If, however, our means of producing and applying light have undergone steady development rather than spectacular transformation, there has been much to occupy us in their adaptation to changing processes and environment. There is no occupation we can pursue and no recreation we can indulge, in which the eyes are concerned, that does not offer problems in lighting. When new uses for light appear we must contrive new devices. Too frequently our progress takes the form of a succession of jerks—a confident advance, followed by a partial retreat as the full consequence of our actions becomes apparent.

A good instance of this mode of development is afforded by the motor car. Each vehicle was, by custom, furnished with its own lights. At once the sources considered adequate for horse-drawn vehicles were found insufficient. With increased speed yet stronger lights were demanded. Concentrated beams, well directed towards the objects requiring illumination, served admirably the needs of the driver of the car. But as soon as the popularity of this new method of transport began to fill the roads, the drawbacks of these powerful beams became apparent. Our own helpful headlights became a menace to oncoming traffic, and to-day the glare from headlights is an outstanding problem. We find relief when entering towns with well-lighted streets, rendering headlights unnecessary.

GREATER BRIGHTNESS AND HIGHER ILLUMINATION.

In the familiar case of the lighting of buildings, experience has been similar. The advent of brighter and more powerful sources was hailed with gratitude. Their general adoption in place of the feebler illuminants of previous ages furnished higher illumination, and enabled us to do easily much that was previously only accomplished with difficulty by artificial light. But the eye quickly wearied of the glare from those brilliant points of light. It was discovered that our gain in light was partially counterbalanced by the depression in vision caused by their dazzle—hence the introduction of measures to diffuse the light.

Other applications of light have involved other special problems. We have found that certain forms of intricate fine work on small objects of dark texture require illumination much in excess of that required for ordinary purposes; that in certain other processes

the direction from which the light comes and the conditions of shadow are of even greater importance than mere brilliancy; that in yet other cases (and, for instance, in the case of industries involving accurate matching of colours) the colour of the light is of great consequence.

In our daily life—in the home, office, and factory—the requisite lighting conditions should be secured in an efficient manner. But there are other cases where pleasing and artistic effect takes precedence of efficiency, and others again—places of entertainment, restaurants, and large stores are instances—where efficiency and cost may fairly be described as of minor importance, provided the desired " attractive " effect is secured.

CO-OPERATION BETWEEN USERS AND PRODUCERS OF LIGHT.

These few examples should serve to illustrate one main characteristic of illuminating engineering—that success in lighting depends in a high degree on co-operation between the installer and the producer of light. The Illuminating Engineering Society occupies a somewhat special position in the freedom with which it welcomes representatives of both these aspects of lighting to its discussions and to its membership. Members of the Society are still engaged in what its original President (Professor Silvanus P. Thompson) described as " a career of self-education." In the long chain of operations connecting the provision of the light with its reception by the human eye of the light that it emits, there are opportunities for many varieties of experts. Besides the technician and the expert on photometry we need the aid of the architect, the artist and the decorator, as interpreters of what is beautiful, dignified or otherwise ministering to our senses and mental impressions; and of the ophthalmologist in whose care rest the requirements of the eye.

But even after we have pooled the advice of these experts on general principles, there remains to be considered the special requirements of the user—by which ultimately the success of an installation must stand or fall.

If personal co-operation between experts is useful, it is even more necessary in the case of organisations. The list of such bodies in some degree concerned with lighting is much more comprehensive than may at first sight be imagined.

ORGANISATIONS FOR THE STUDY OF LIGHTING.

Amongst the societies and organisations specially concerned with illumination there are the Institutions of Gas and Electrical Engineers, and the various commercial and organising bodies connected with the gas and electrical industries. Amongst these one might mention the National Gas Council, the Society of British Gas Industries and the British Commercial Gas Association on one side: the British Electrical Development Association, the Incorporated Municipal Electrical Association and the Electric Lamp Manufacturers' Association on the other. There are likewise such professional bodies as the Association of Public Lighting Engineers and the Royal Institute of British Architects, which are necessarily interested in illumination in connection with their daily work, and other bodies, such as the Master Sign Makers Association, the Design and Industries Association and the Incorporated Institute of British Decorators, who have a direct share in the craftsmanship of lighting. One ceases to enumerate such bodies only because it is necessary to set a limit to the length of this address; actually it would be difficult to name any trade or technical body that is *not* in some degree interested in lighting!

One may, indeed, visualise all such bodies as arranged in the form of a celestial chart, with the Illuminating Engineering Society occupying a central position—itself less imposing than many of its older and longer established neighbours, but important in that it serves as a centre of activity for the whole system so far as lighting is concerned.

RESEARCH.

Linked to the Society there are, however, a series of other organisations specifically concerned with enquiry and research. There is:

1. The National Illumination Committee on which leading technical societies and some Government Departments are represented, and which serves as a link with similar committees in other countries; all these report to the International Commission on Illumination.
2. The British Standard Institution, to whom lighting problems are brought when they are ripe for standardisation.
3. The Illumination Research Committee, operating under the Department of Scientific Research, which initiates many researches desirable in the public interest such as could not readily be dealt with by other means.
4. The National Physical Laboratory, which is intimately associated with the above, furnishing the essential link for the actual carrying out of experiments.

On the numerous technical committees operating under (1), (2) and (3), members of the Illuminating Engineering Society play a leading part. As Sir Francis Goodenough, a Past-President of the Society, has declared, there is nothing derogatory in the Society thus sharing its tasks with other bodies. This action merely carries into effect its declared policy, i.e., enlisting aid whenever available in the belief that the wider the web of organisations interested in illumination, the greater will be the ensuing benefits to the lighting industry and to the public.

This short sketch will serve to show that the machinery for dealing with illumination on the technical side is fairly comprehensive. On the whole, it may be said to work smoothly and well, as was illustrated at the International Illumination Congress (1931), when these various units combined their efforts with such signal success.

THE LIGHTING INDUSTRY.

We come now, however, to a somewhat different matter—the organisation of the lighting industry of this country. Here there is certainly less evidence of cohesion. Indeed, few people recognise this industry for what it is—perhaps the most fundamental of all our national industries. There is no one to-day in his home, in his occupation and in his amusements who is not dependent on artificial light.

Light is, in fact, the commonest and most universally applied of all tools. There is no industry that could be carried on without its aid.

But, apart from this, the number of trades interested in the actual supply of light is very numerous. Even to-day, when applications of gas and electricity have become so much more numerous and varied than in the past, the use of both (and, therefore, of the coal from which both are ultimately mainly derived) for the purpose of yielding LIGHT remains a substantial and important part of the total production.

HOW ADVANCES CREATE MORE BUSINESS.

It can be readily imagined how improvements in lighting conditions or new applications of light create business or employment in various other trades. Consider the impetus given to a long series of operations, when a city resolves on completely modernising its lighting.

Consider, again, the influence on other industries of a campaign for better lighting, and of the remedy of

conditions admittedly inefficient—the modernisation of obsolete industrial lighting, for example.

New needs, new applications of light quickly build up new industries. Such new fields as aviation lighting quickly result in the development of specialised equipment. The development of architectural lighting, flood-lighting, luminous gaseous tubes—all these have brought in their train employment for workers in glass and metal, and many subsidiary trades. A good example of this tendency is furnished by the manufacture of traffic signs and signals, on which many firms are now engaged—an industry that seems to have grown with the rapidity of the prophet's gourd!

RECENT ADVANCES IN LIGHTING TECHNIQUE.

New devices new methods, and new materials are constantly changing lighting technique as well as developing new sections of industry. Some instances are to be seen at this Exhibition. Amongst them may be mentioned the development during recent years of neon tubes in varied colours, which now play such an important part in publicity by means of light; the new hot cathode electric discharge lamps, still in course of development, which are exciting so much interest as a medium for street lighting; the continually extending use of stainless steel, both in the form of reflectors and as a decorative material; and the applications of the new synthetic plastic materials to lighting fittings, for reflecting surfaces and, possibly, for translucent materials as well.

The widespread use of polished metal in decoration is specially interesting in view of the fact that it compels the use of diffusing materials to diminish the brightness of sources to a moderate value. Granted that this condition is observed, such polished surfaces may even form the basis of indirect lighting schemes—as has been done in certain modern theatres.

The possible use of synthetic plastic materials likewise is full of interest—especially in connection with the production of pendant fittings of extensive area but moderate weight.

In other respects the British Industries Fair is illustrating the applications of artificial light. In accordance with its traditional practice the general interior lighting is shared, approximately equally, by electricity and gas. In the grounds of the Fair there are also to be seen examples of modern outdoor lighting with both illuminants.

HOW BUILDING AFFECTS THE LIGHTING INDUSTRY.

In order to illustrate how widespread may be the effect of decisions on principle, as well as modifications in technical practice, let us next consider in turn one or two " topics of the day."

The first of these is the cancellation of new building operations—possibly a necessary step in the crisis from which (let us hope) we are now emerging, but one which undoubtedly accentuated unemployment. Initially the drawbacks of this measure of economy were regarded as applying only to the building industry and its allied trades. Actually they echoed through a long series of subsidiary industries—furnishing, painting and decorating, window glass making, plumbing, gas and electric supply undertakings, electrical contracting, manufacture of cables, pipes, switchgear, fuses, lamps and mantles, glassware, metal work and lighting equipment of every description. This is surely a topic on which the voice of the lighting industry should be heard?

INTERIORS FROM WHICH DAYLIGHT IS EXCLUDED.

Take next another problem, likewise associated with building. Already there exist—cinemas and theatres are familiar examples—buildings expressly designed for use by artificial light: natural lighting has become a minor matter, in some cases entirely omitted. In the case of blocks of buildings in congested city areas, access of daylight is at the best imperfect and so costly as to be almost prohibitive. It is accordingly now being suggested that in such circumstances the effort to furnish natural lighting should be abandoned, and that effort should be concentrated on the provision of adequate artificial lighting. Is there anything inimical to health in this procedure? Can such objections be met? And can such buildings be regarded as admissible from the hygienic standpoint?

CITIES OF THE FUTURE.

This is a question of the moment to the lighting industry, especially in view of the fact that in the future increasing height of buildings and other developments seem likely to accentuate the need for artificial lighting at the lower levels. The city of the future has been visualised as consisting mainly of immense flat-topped buidings, rising in terraces from ground level, the upper walks serving for pedestrians who would be provided with connecting bridges crossing the roadways at intervals. Roadways at ground level would be used exclusively by motor traffic. If there is any truth in this picture, it seems evident that at ground level lighting would be mainly artificial.

GAMES BY ARTIFICIAL LIGHT.

But leaving this possibly fanciful picture we can imagine other directions in which artificial light, rather than daylight, tends to become the predominant illuminant. Theatres and cinemas have been mentioned as familiar instances of this tendency. Evening recreation, athletic or otherwise, for those engaged in their vocation during daylight hours, inevitably requires artificial light. The recognition of this fact is bound to affect profoundly the design of buildings to serve this end. We have in our greyhound racing tracks, indoor tennis courts and badminton courts, and night-swimming baths, instances of sports conducted freely by artificial light. The experiment of " floodlit football" is under trial already with fair success, considering the great natural difficulties—such as the capricious atmosphere effects of rain, mist, and fog. Is it too fanciful to suggest—as has recently been done—that football, athletic contests, and other sports may, in the future, take place in a vast covered stadium where diffused artificial lighting, resembling light from the natural sky, is by no means unattainable?

However, turning aside from speculations, there are many present lighting problems of admitted urgency and importance.

LIGHTING IN SCHOOLS AND FACTORIES.

The natural and artificial lighting of many school-buildings is admittedly poor. Whilst in up-to-date factories excellent equipment is now usually installed, in many of the older buildings antiquated and imperfect arrangements persist. Visitors to the International Illumination Congress (1931) were frankly horrified at the lighting of certain works they were invited to visit. In the course of a recent report by one of H.M. Inspectors of Factories it was recorded that, despite some bright examples, little progress was revealed as compared with conditions in the same area twenty years ago!

Now this is a question that should interest all present whether they are users or producers of lighting equipment. Such progress as has been made has been in no small measure aided by the sympathetic interest which the Home Office Factory Department has taken in the subject of industrial lighting. The present Chief Inspector of Factories, Mr. D. R. Wilson, a past president of our Society, has recently pointed out in his annual report that Britain, almost alone amongst the civilised countries, has, even now, no specific requirement of adequate lighting in its Factory Act—although this step was advocated just twenty years ago by a Departmental Committee. This measure is needed, not by up-to-date and enterprising managers of factories who know that good lighting is an economic necessity,

but in order to bring in line those who have lagged behind in the general advance and will otherwise pay the penalty for their neglect in the form of prejudice to health and impaired production and efficiency.

Whilst we still lack a really scientific basis for the determination of values of illumination necessary for different purposes—(this need the Illuminating Engineering Society is now attempting to satisfy)—there is ample evidence that in many directions lighting conditions fall far short of modern needs.

PUBLIC LIGHTING.

Another field where the standard of lighting has lagged behind modern requirements is street lighting. Although many recent installations of outstanding interest could be mentioned, it is yet true to say that the general standard is not very much above that prevailing before the war. Yet in the meantime the volume and speeds of modern traffic have increased by leaps and bounds. This question is surely one of vital public importance in view of the ever-swelling records of fatalities in our streets and the recognised fact that the proportion of accidents occurring by night tends to increase steadily—doubtless a consequence of main roads being used by night to an ever increasing extent.

The task of a driver in rapid traffic might well be compared, in terms of effort, with operations in a factory, where a minimum of 5 foot-candles is regarded as essential for fine work. (In modern factories twice or even three times this value is not unusual.) Now a class " F " street, about mid-way down the list in the British Standard Specification, and regarded as moderately well lighted, receives only 0.05 foot-candles —only 1/100th of that approved for factory lighting and, incidentally, about 1/10,000th of the average value of unrestricted daylight-illumination from an overcast sky (i.e., about 500 foot-candles). Even a class " A " street (allotted 2.0 foot-candles, a value almost unknown at present) would be receiving in parts only 1/250 of the daylight value.

We can see from this how very far the artificial lighting achieved by man in our street lags behind that furnished by Providence, and we need not wonder that the accident risk by night is considered very much greater by night than by day—according to some American experts approximately four times as great.

The problem of public lighting is complicated by the fact that many roads now fulfil functions quite different from those for which their lighting was originally designed. We have, in particular, a new species of road, the arterial roads connecting cities, and used mainly by travellers from afar rather than by inhabitants of the scattered parishes through which they pass. Small wonder that the latter are inclined to argue their liability to bear the cost of public lighting! There is, indeed, at least a case for the contention that this " lighting of the King's Highway " should be regarded as a national rather than a parochial duty; and that the Ministry of Transport, which already concerns itself with the cost of laying out and maintaining roads, should assume a greater degree of responsibility for their illumination.

We see, therefore, how at least two Government Departments, the Home Office and Ministry of Transport, must be regarded as in some measure concerned with illumination, and there are others. The Ministry of Aviation must naturally occupy itself with aviation lighting, and who can assume what tasks this may impose in the future? The Ministry of Mines is already closely interested in their lighting, and it is difficult to believe that the Ministry of Health will escape from any association with such an essential condition of human well-being as light.

A NATIONAL COUNCIL FOR THE LIGHTING INDUSTRY?

To the lighting industry the manner on which Government Departments may ultimately participate in the control of illumination is surely a matter of moment, and it should be prepared to participate in any arrangements that may be made to furnish technical guidance.

At the moment our chief wish is to have all sections of this great lighting industry appropriately represented in the Illuminating Engineering Society, which opens its doors to all interested in the application of light in the service of mankind.

But, ultimately, one might forecast the formation of an Advisory Council for the Lighting Industry which would serve to bring its scattered components into closer association and would interest itself in the study of these big questions with which the future of the industry is so closely linked.

This sketch of the position of to-day in regard to artificial lighting—this vista of what its future may unfold—has, I hope, impressed upon you not only the advantages, but also the necessity of our Illuminating Engineering Society.

When so much important work requires to be done, and when its results have to be conveyed to the towns and industries, the offices and homes of the nation, organisation becomes paramount. The best organisation for the purpose is that embracing all interests, which effectively unites all associated with it, and which carries into effect decisions that are the result of careful consideration and discussion by all its members.

Our Society offers that opportunity and is prepared to assist this vast industry by encouraging its members to foregather—in various parts of the country—at meetings where appropriate subjects can be discussed, where modern applications may be exhibited and—what is of even greater interest to many—where up-to-date installations may be inspected and examined in detail.

A brief opportunity was afforded for the discussion of the address before the audience broke up to resume their study of the Fair.

Mr. CECIL HUGHES pointed out an important distinction between industrial lighting and school and street lighting. It was the factory owner's own fault if, by indifference to good lighting, he lost the benefits of it. But in schools and streets the users suffered silently under bad lighting.

It was most important, therefore, that public bodies should interest themselves in this subject. In regard to arterial roads it was evident that the lighting should be supervised by some central authority.

Mr. W. J. JONES referred to domestic lighting, in which progress was constantly being made. The advantages these offered were apt to be overlooked because builders and contractors were not familiar with the latest developments.

Capt. W. J. LIBERTY also alluded to problems involved in the lighting of arterial roads, and to the transitions between town lighting of varying brightness and the dark, open country between. Some form of controlling authority was evidently necessary.

Dr. J. W. T. WALSH emphasised the need for educational work and commented on the valuable service of THE ILLUMINATING ENGINEER.

Mr. J. H. BURMAN emphasised the need for some authoritative ruling on the classification of arterial roads, e.g., some indication as to which class in the B.S.I. Specification they should fall within.

Mr. A. CUNNINGTON agreed with Mr. JONES in regard to the need for education of the public in lighting matters. He had frequently been struck by the prevailing ignorance of recent progress. There was too strong a tendency to perpetuate methods of the past. It was very desirable that the Society should exercise more influence on contractors in order to ensure speed up advances in lighting.

Literature on Lighting*

(Abstracts of recent articles on Illumination and Photometry in the Technical Press)

(*Continued from page 94, March, 1934*)

I.—RADIATION AND GENERAL PHYSICS.

68. Fundamental Properties of the Electron. A. T. Waterman.

Elect. Engineering, 53, *No.* 1, *p.* 3, *January*, 1934.

A simple account of the fundamental properties of electrons, including diffraction patterns from electron beams. S. S. B.

69. The dependency of light emission of selective radiation on surface brightness and the invalidity of Lambert's distance law with small intensities. H. Bertling.

Licht und Lampe 23, *No.* 4, *p.* 82, *February* 15, 1934. *No.* 5, *p.* 130, *March* 1, 1934.

With monochromatic or coloured light such as is given by discharge lamps, at low intensities, special account has to be taken of the part played by the rods and cones of the retina in estimating visual acuity. The author enunciates the rule that rays whose maximum energy emission is at $\lambda < 5550$ A° give greater acuity with decreasing surface brightness the nearer the radiation maximum lies to $\lambda = 5100$ A° and gives examples from different types of discharge tube. E. S. B. S.

II.—PHOTOMETRY.

70. The Avoidance of Results of Departure from the Cosine Law in Photometry. O. Hopcke.

Das Licht, III., *pp.* 41-43, *March* 15, 1934.

The author illustrates by the aid of lantern slides the results of departures from the cosine law in photometry, which are most evident in the case of diffusing services intended to measure horizontal illumination. Various devices to counteract the effect of imperfect diffusion are mentioned, such as the use of small translucent spheres embodied in an illumination-photometer produced in Germany. The difficulty is acute in the case of photo-electric surfaces which are usually smooth and polished. The author illustrates a surface of this type which is turned up at the ends in order to effect partial compensation for the error. J. S. D.

71. Description of the apparatus, used in the tests carried out by the " Société pour le Perfectionnement de l'Eclairage " in order to determine the reflection characteristics of the various surfaces used in streets. M. Cohu.

R.G.E., 35, *pp.* 147-155, *February* 3, 1934.

Describes in detail the tests made by the S.P.E. on the reflection characteristics of street surfaces. The author discusses the insufficiency of the notion of illumination as a criterion of lighting, and points out the importance of surface brightness. He goes on to describe the tests made, and the apparatus used in these tests, and finally discusses the precision of the apparatus. W. C. M. W.

72. The Illumination-Response Characteristics of vacuum Photoelectric Cells of the Elster-feitel type. J. S. Preston and L. H. MacDermott.

Proc. Phys. Soc., *Vol.* 46, *part* 2, *No.* 253, *p.* 256, *March* 1, 1934.

The authors deal with the present status of the vacuum photo cell as regards proportionality of photo-electric current to illumination, and give a series of observations which show that, while excellent cells are available, their employment for precise work without previous test is unsafe. A theory is developed which accounts for the observed results and gives over a limited range an equation of the form $S = K_1 + K_2/\sqrt{E}$ where S is the cell-sensitivity, and E the illumination. Attention is called to the dependence of the illumination characteristic upon the colour of the light employed. The bearing of the theory on the application of Talbot's law to non-linear photocells is discussed.

J. M. W.

III.—SOURCES OF LIGHT.

73. Neon Sign Production. Anon.

El. Review, *Vol. cxiv.*, *No.* 2,935, *p.* 264, *February* 23, 1934.

Describes the manufacture of cold cathode discharge signs at the works of the Claude General Neon Lights, Ltd.

J. M. W.

74. 10,000 Lumen Sodium Units Light Revere. Anon.

El. World, 103, *pp.* 294-295, *February* 24, 1934.

This article describes the installation of sodium vapour lamp street lighting at Revere, U.S.A. The lamps consume 250 watts each, and have an efficiency of 40 lumens per watt. The reflecting equipment used is of aluminium, producing a maximum intensity of about 2,500 candles. The lamps operate on a 6.6-amp. series circuit.

W. C. M. W.

75. The Characteristics of the Sodium Lamp as Influenced by Vapour Pressure. G. R. Fonda and A. H. Young.

J. Opt., Soc., Amer., *Vol.* 24, *No.* 2, *p.* 31, *February*, 1934.

The light output and luminous efficiency of sodium lamps are both functions of the vapour pressure, being a maximum at a temperature of 200° C. Results are given of tests on lamps run in ovens at various temperatures, together with a theoretical explanation of the phenomena.

J. M. W.

IV.—LIGHTING EQUIPMENT.

76. Lighting Control over a Large Area. Anon.

El. Review, *cxiv.*, *No.* 2,935, *p.* 264, *February* 23, 1934.

Describes a method of control of street lighting circuits by means of cascade relays, one of which is located at the end of each section to control the succeeding section. Provision is made for hand switch-

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* Abstracts are classified under the following headings: I, Radiation and General Physics; II, Photometry; III, Sources of Light; IV, Lighting Equipment; V, Applications of Light; VI, Miscellaneous. The following, whose initials appear under the items for which they were responsible, have already assisted in the compilation of abstracts: Miss E. S. Barclay-Smith, Mr. W. Barnett, Mr. S. S. Beggs, Mr. F. J. C. Brookes, Mr. H. Buckley, Mr. L. J. Collier, Mr. H. M. Cotterill, Mr. J. S. Dow, Mr. J. Eck, Dr. S. English, Dr. T. H. Harrison, Mr. C. A. Morton, Mr. G. S. Robinson, Mr. W. R. Stevens, Mr. J. M. Waldram, Mr. W. C. M. Whittle, and Mr. G. H. Wilson. Abstracts cover the month preceding the date of publication. When desired by readers we will gladly endeavour to obtain copies of journals containing any articles abstracted and will supply them at cost.—Ed.

ing, half-night lighting, etc. The system is in use at Mulhausen.

J. M. W.

77. Plaza Lighting. L. R. Need.

El. Journal, 31, *No.* 2, *p.* 59, *February*, 1934.

Briefly describes the lanterns, and, in more detail, the posts employed in the lighting of the Plaza of the Cincinatti Union Terminal. The posts are of centrifugally cast concrete, 23 feet in height, and are arranged for flush mounting on the surface, for structural reasons. Brief results of mechanical tests are given.

J. M. W.

78. Sodium Vapour Floodlights Come Next. Anon.

El. World, 103, *p.* 200, *February* 3, 1934.

A photograph shows one of the floodlights used on the General Electric building in New York. The reflecting surface is of aluminium alloy, and the floodlight houses a 10,000 lumen sodium vapour lamp.

W. C. M. W.

V.—APPLICATIONS OF LIGHT.

79. Papers on Lighting: a Century of Progress Exposition. W. D'A. Ryan, L. A. S. Wood and C. J. Stahl, J. L. Stair, W. V. C. Foulks, W. E. Folsom, C. M. Cutler.

Am. Illum. Eng. Soc., Trans. 29, *p.* 107, *p*, 116, *p.* 119, *p.* 139.

Four papers giving detailed descriptions of the lighting at the Chicago Exposition. Many half-tone and coloured illustrations are reproduced.

G. H. W.

80. Developments in the Electrical Industry during 1933.—Lighting. J. Liston.

Gen. El. Review, 37, *pp.* 57-63, *January*, 1934.

An account of developments in lamps and lighting apparatus in 1933.

G. H. W.

81. Light and Architecture. Anon.

Am. Illum. Eng. Soc., Trans. 29, *pp.* 97-106, *February*, 1934.

Illustrated descriptions of eight modern lighting installations in the U.S.A.

G. H. W.

82. Lighting Revolutionised by Science of Seeing. M. Luckiesh.

El. World, 103, *pp.* 263-268, *February* 17, 1934.

The article points out that although great advances have been made in the production and control of light, the physiological and psychological aspects of seeing are not so well known as they might be. The author gives a brief outline of the principles and practice of the science of seeing, stressing the need for a means of specifying requirements, and showing how to obtain such a specification.

W. C. M. W.

83. Modern Lighting and Air Conditioning. A. L. Powell.

El. World, 103, *p.* 225, *February* 10, 1934.

Describes the lighting installation in a ladies' waiting-room connected with the studios of the National Broadcasting Company. Special ceiling and wall fixtures, as well as floor and table lamps, are used.

W. C. M. W.

84. The Heating Effect of Artificial Lighting. W. Sturrock and J. H. Walter.

Am. Illum. Eng. Soc., Trans. 29, *pp.* 23-45, *January*, 1934.

Results are given of an investigation into the heating effects of an electric lighting installation. Test results for a typical interior are recorded for various amounts of lighting. An analysis is made of the relative importance of the factors which contribute to the heating in an interior. The general problem of reducing the heating is discussed and data are given for the cooling effect of an air current through a lighting fitting.

G. H. W.

85. On the Conditions necessary to secure faultless Illumination of Desks and Typewriters. G. Nilsson.

Das. Light III., *pp.* 44-48, *March* 15, 1934.

The author analyses the chief faults in lighting writing tables, typewriters, etc., such as troublesome shadows from hand or body or reflected glare. Charts are presented showing the areas where such faults exist, with various positions of lamps and suggestions for their elimination are made.

J. S. D.

86. The Lighting of the National Route from Paris to Versailles. R. Brugnon.

B.I.P., 64 *pp.*, 24-26, *February*, 1934.

The route falls into three divisions, the first of which is lighted by incandescent lamps in lanterns equipped with prismatic or mirrored glass. The second includes a tunnel illuminated by double filament (300/100 w.) lamps, so that 300 watts is expended by day and only 100 watts at night. The change is effected automatically when daylight fails. The final section is illuminated by 100 watts d.c. sodium lamps.

J. S. D.

87. Some Mine-Lighting Practices in the United States. C. W. Owings.

Am. Illum. Eng. Soc., Trans. 29, *pp.* 47-63, *January*, 1934.

After an historical introduction candle-power and illumination data are given for acetylene and electric cap lamps for use in mines. The relation between illumination and accidents in mines is considered.

G. H. W.

88. Shop Lighting. R. O. Ackerley.

Elect. 112, *p.* 294, *February* 23, 1934.

An abstract of the above is given, including a summary of the character of shop-window lighting, and its relation to the nature of the goods displayed.

C. A. M.

89. Modern Lighting in Japan. Anon.

Elect. 112, *p.* 253, *February* 23, 1934.

A number of photographs of present-day lighting of streets and buildings in Japan form good examples of the preservation of characteristic features, with suitable modern equipment.

C. A. M.

90. Photoelectric Cells. H. R. Ruff.

Elect. 112, *p.* 304, *March* 2, 1934.

In a summary of present-day use of photoelectric cells, reference is made to the control of street and interior lighting. For street lighting it is recommended that control should operate when the illumination from daylight has fallen to a value of 1 foot-candle.

C. A. M.

91. The Response of Greenhouse Crops to Electric Light Supplementing Daylight. R. B. Withrow.

Am. Illum. Eng. Soc., Trans. 29, *pp.* 65-74.

The data given indicate that quite low illuminations supplied at night to supplement daylight increases flower production and earliness in flowering in certain crops. Certain parts of the spectrum appear to be of greater value than others in some cases. Names of plants concerned are given.

G. H. W.

Visits to Glyn Mills and Co. and Unilever House

Members of the Illuminating Engineering Society had a treat on March 22, when they visited in succession the premises of Glyn Mills and Co., in Lombard Street (over which they were personally conducted by Lord Wolverton), and Unilever House. We hope to give an illustrated description of these installations, which presented an interesting contrast in regard to the use made of general and local lighting, in a forthcoming issue.

Recent Patents

(Abstracts of recent Patents on Illumination & Photometry.—D. K.)

Spec.: No. 403,317, Improvements in and connected with Safety Igniting Device for Gas Burners.

Many such devices are already known, but in this invention the flow from the diaphragm actuating chamber of the main valve and the flow to the pilot burner each pass through a separate valve, and the two then only combine in a common outlet-space. In the claim it is stated that by this invention the flow of gas from the main and the flow to the pilot are separately controlled by two or more valves of the safety type controlled by a common thermal element.

Spec.: No. 403,323, Improvements in and relating to Electric Lamps.

The invention relates to bases for electric incandescent lamps, and more particularly when such bases are made of moulded material. A cylindrical body having ridges in the sides extending substantially parallel to the axis, the ridges being wholly or in part composed of conducting material forming conduct terminals of the lamp or like device. A socket suitable to receive the lamp or like device has a cylindrical hollow with grooves in the sides thereof, in which terminal contact pieces are located.

Spec.: No. 403,408, Improvements in the Control of the Flow of A.C. through Electronic Discharge Tubes.

In broad lines the invention consists of the combination of an electronic discharge tube connected in circuit with a source of alternating potential and an oscillating circuit in which an oscillating voltage is adapted to be initiated in synchronism with said alternating potential, which oscillating voltage is impressed upon the grid of said tube, whereby said tube is rendered conducting or non-conducting to the positive half waves of said alternating potential according as whether the frequency of said alternating potential varies in one or the other direction from a given frequency.

Spec.: No. 403,428, Improvements in Electric Discharge Devices.

The invention relates to positive column discharge device adapted to be used as lamps on low voltage circuits, and to provide a positive column discharge device having improved means by which the operation of the lamp is started. Claim 1. An electric discharge apparatus comprising an electric positive column discharge device having a plurality of auxiliary anodes or groups of anodes between the main anode and cathode, and connected to the main anode through resistances, wherein the resistances progressively decrease in value as the distance between the cathode and the auxiliary anode, or groups of anodes, to which each resistance is connected, increases.

Spec.: No. 403,489, Improvements relating to Electric Discharge Tubes.

The invention relates to electric discharge tubes, and in particular to luminous discharge tubes furnished with a filling of neon or other gas, such as are employed in luminous signs. The invention is particularly concerned with the connection for bringing in high voltage supply to the electrodes of such discharge tubes, and may be employed with advantage in any case in which a high tension connection is to be effected between an electrode of a discharge vessel and a high tension cable.

Spec.: No. 403,521, Improvements in or Relating to Vehicle Road Lamps.

According to the present invention, a vehicle road lamp is provided at the front in a position in advance of the body, so as to be illuminated by light proceeding from the interior of the lamp, and to be visible to the driver or rider of the said vehicle as an index of whether the lamp is lighted or not, with a lens, transparent or translucent plate, reflector, or the like.

Spec.: No. 403,527, Improvements Relating to Gas-Heated Heating Apparatus.

The invention comprises the combination of a concave reflector, an axially disposed atmospheric burner, preferably of the Meker type, a bracket carried by the burner, and a refractory body of disc-like form mounted on the bracket so that the burner flame can impinge upon one face of the said body, the arrangement being such that the heat is directed on to the reflector from the heated face of the refractory body.

Spec.: No. 403,541, Improvements in Luminous Tube Signs.

The chief improvement, according to the present invention, consists in making the illuminated outlines widened with employing larger diameter tubes for the purpose, or impairing the brilliancy. A further object is to produce a self-contained portable boxed sign employing luminous tubes, wherein electrodes, connections, and transformer are snugly and compactly housed in a single unit, capable of being plugged into any available source of current.

Spec.: No. 403,587, Improvements in and Relating to Gas Igniting Devices.

An igniting filament such as a platinum wire is supported in the end of a portable holder that may be connected by a flexible lead to a plug-in point in an electric circuit. A reflector is situated behind the filament, and the holder is provided with a manually operable switch. When in use the igniting device also illuminates the place—such as the inside of the gas oven—where the gas is to be lighted.

Spec.: No. 403,626, Improvements in and Relating to Photo-electric Devices.

This invention relates to system for employing photo-electric device for making measurements, or for controlling a device in accordance with the light received from particular material. It is the object of this invention to provide and improve the system of this character, which is simple in construction, reliable in operation, and at the same time is not too costly to produce.

Spec.: No. 403,633, Improvements in or Relating to Lamp Shades for Billiard Tables.

The invention comprises the series of three square shades with individual lighting, the inner sides of the shades are cut away to allow spread of light. The shades are supported by two runners on top and then hung from the ceiling. The shades are made of plywood, sheet tin, or pasteboard.

Lighting at the British Industries Fair

THE British Industries Fair in Birmingham, at which a Conference of the Illuminating Engineering Society was arranged for the first time, was certainly quite as successful as in past years. The Fair was crowded.

The general lighting of the interior of the Fair does not call for any special comment, but an enterprising effort was made to arrange for outdoor lighting. This included (1) the lighting of a model street, 600-700 ft. long, by low-pressure gas lamps, furnished by Messrs. Wm. Sugg and Co., Ltd.; (2) the lighting by means of electric discharge lamps of the colonnades adjacent to the building; and (3) the floodlighting of the entrance with coloured Osira lamps, for which the General Electric Co., Ltd., were responsible.

A feature of the outdoor lighting, adjacent to the exhibit of the famous " Royal Scot," was the section of roadway, 220 yards long, lighted with the new Sieray " W " lamps, giving a daylight effect.

In the Gas Section there were exhibits by a number of leading firms, including Messrs. W. Sugg and Co., W. Parkinson and Co., Evered and Co., and Lighting Trades, Ltd. At the stall of the first named one was struck by some pleasing interior fittings and by the hospital and dentists' lamps (the latter with a screen giving a blue light). Messrs. W. Parkinson and Co. had on exhibit a new chart for determining positions of street lamps and the resultant illumination and some ingenious models illustrating isocandle diagrams. Lighting Trades, Ltd., in addition to their standard display of mantles, showed some pleasing " case " type decorative fittings, designed on lines quite similar to the latest forms of electric lighting.

In the Electrical Section there were naturally many exhibits of interest, even if not all the leading firms in the lighting industry were represented. The stalls of several exhibitors were assembled in an exceptionally interesting way. One liked the display (on cardboard models of famous buildings) of coloured floodlighting at the G.E.C. stall, where Osira lamps and lanterns were naturally in evidence, but many other interesting things (such as the new luminous traffic control device with which the company is associated) were to be seen. The British Thomson Houston Co., Ltd., had an effective series of translucent pictures of lighting installations, outlined with tubular lamps, and pillars bearing Mercra discharge lamps and lanterns. Features of the stall of Revo Electric, Ltd., were the latest types of street-lighting units, including lanterns developed for electric discharge lamps and traffic devices. Two items that might be picked out from the contents of the stall of Simplex Electric Co., Ltd., are the robustly constructed flameproof fittings now introduced for use in mines, which are stated to have satisfied the most exacting tests, and the new Simplex-Credalux lighting fittings exhibited for the first time. Amongst these one noted especially the spherical globe and the elegant " Papillon " fittings for use with tubular lamps. Other attractive displays of fittings and glassware were those of L. G. Hawkins and Co., Ltd., S. and W. Lighting, Ltd., and Beantree Illuminations, Ltd., whilst Messrs. Chance Bros. and Co. were responsible for an originally conceived stall well displaying the variety of glass products with which they are identified.

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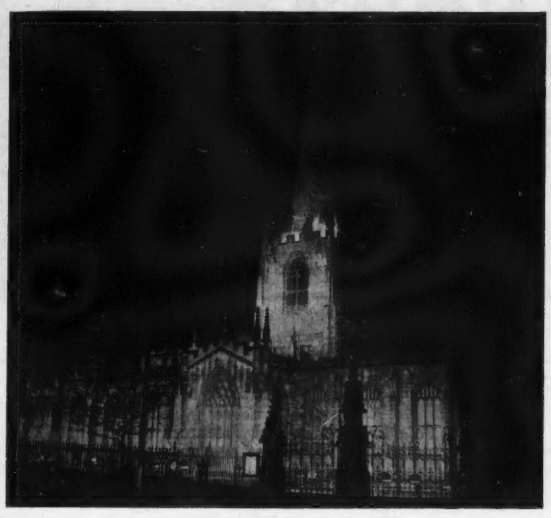

There seems to be no doubt that public interest in floodlighting is very real and is increasing. During the last twelve months we have reviewed a number of the more interesting installations, and as improved financial conditions become more general we may expect that there will be a very big demand for this type of lighting, which has hitherto been regarded as somewhat of a luxury.

Among recent floodlighting installations, those in which gas projectors were used have been varied and usually effective. One of these which comes to mind is the floodlighting of Exeter Cathedral on the occasion of its 800th anniversary last November.

A more recent installation, and one which we illustrate here, is the floodlighting of Sheffield Cathedral. In this case the lighting was obtained from forty-four lamps of the Foster and Pullen (Bradford) type, varying from 500 to 2,000 candle-power. These were placed approximately six to eight feet apart and thirty-six feet from the building line.

A New Adjustable Lamp

From Messrs. Herbert Terry and Sons, Limited, the famous makers of springs, presswork, wirework, etc., we have received particulars of an interesting adjustable lamp. As will be seen from the illustration reproduced here, the essential feature of the lamp is the arrangement of the carrying arms, and their respective springs, whereby so good a balance is achieved that the lamp may be moved practically universally with the lightest of touches.

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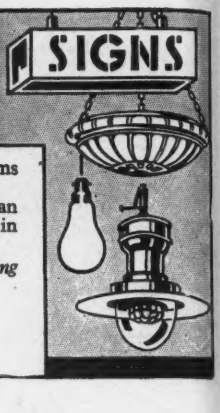

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Seamless Steel Lighting Standards.
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AUTOMATIC CONTROL of STREET and FACTORY LIGHTING
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Literature, Etc., Received

From the GENERAL ELECTRIC CO., LTD.

A tastefully prepared folder dealing with a number of new designs in domestic electric light fittings. We note many table lamps of unusual design and a quantity of pendant and wall fittings. Three floor standards are shown, including one of the new "indirect" type, with inverted funnel reflector. All the designs embody chromium features.

From SIEMENS ELECTRIC LAMPS AND SUPPLIES, LTD.

A leaflet dealing with the new Siemens range of Sphere lighting fittings. These are available in two finishes, viz., toned bronze and chromium plated, at prices varying between 11s. and 29s. 6d., and accommodate lamps from 40 watts to 300 watts.

From the NEWCASTLE-UPON-TYNE AND GATESHEAD GAS CO.

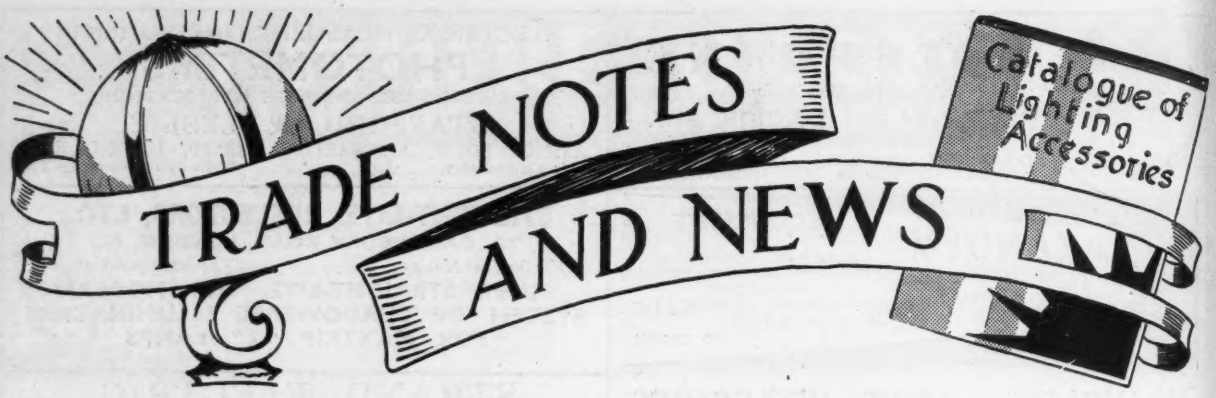
The annual Year Book is an extremely well produced booklet of 32 pages, printed throughout in red and black and containing much useful and informative matter. All the uses to which gas is put are dealt with, including domestic refrigeration.

Patent Offered

THE proprietor of British Patent No. 268293, dated March 25, 1926, relating to "AUTOMATIC CUT-OFF VALVE," is desirous of entering into arrangements by way of a licence or otherwise on reasonable terms for the purpose of exploiting the above patent and ensuring its practical working in Great Britain. Inquiries to B. Singer, Steger Building, Chicago, Illinois.

Straight-Lite Reflectors

We are asked to correct an error which occurred in our last issue. In a notice dealing with the Super Straight-Lite Reflector we inadvertently reproduced the incorrect block, which shows an old type of reflector. The new type of Straight-lite reflector is a considerable improvement on the type shown and is fully illustrated in their most recent list.



Electrical Handbook for Women

We have been favoured with advance particulars of a new publication, "The Electrical Handbook for Women," which is to be published by Messrs. Hodder and Stoughton early in April. The book has been compiled by the Electrical Association for Women, and is divided into four parts. Part I. deals with the General Principles of Electricity, Part II. with Law and Tariffs, Part III. with particular Domestic Applications of Electricity, and Part IV. with Teaching and Demonstrating.

The subjects appear to have been dealt with most comprehensively, the "Domestic" section in particular dealing with all possible ramifications of the subject.

The book is obtainable, post free, from the Electrical Association for Women, 20, Regent-street, London, W.1, at a cost of 5s. 6d.

A New Lightmeter

We have noted frequently that to the layman (as opposed to a trained lighting engineer) the *problem* of measuring the actual amount of light which is available from any given source or installation is one which has always presented certain difficulties. It gives us pleasure, therefore, to be able to acknowledge the receipt from the Benjamin Electric, Ltd., of particulars of a new light-measuring instrument known as the Benjamin Model "B" Lightmeter. This gives direct reading—that is to say, that it indicates visually, by means of a moving needle and with an accuracy quite sufficient for all but laboratory purposes, the amount of light (measured in foot-candles) falling on any particular surface.

The instrument is self-contained, weighs only 10 oz., is $4\frac{5}{8}$ x $2\frac{5}{8}$ in., and is priced at 96s.

The only criticisms that occur to one are that the scale deals with relatively high illuminations only, and that the "grading" of illumination according to the task might perhaps be modified with advantage.

Firms having new or interesting products which they wish to bring before the notice of the public are invited to make use of the Trade Notes Section. Matter, which should preferably be accompanied by a block or illustration, should reach the offices of "The Illuminating Engineer" not later than the 15th of the month prior to publication.

Gas Delivered to the Door

An interesting prediction was made recently by Sir Francis Goodenough with reference to the increasing use of gas as an illuminant. He mentioned the fact that gas cylinders filled with compressed gas have been supplied by the Birmingham gas undertaking for use on small yachts for lighting and cooking, and went on to foresee the day when, in rural areas where at present there are no gas mains, gas may be delivered at the doors like coal, bread, or milk. Sir Francis's prophecy gives food for thought, for while the scheme seems practicable from the suppliers' point of view, the method of connecting the cylinder to the cooking or lighting unit would naturally require some study in order to eliminate want of care on the part of the unskilled.

Light to Lhasa

An order of considerable interest was recently completed by the General Electric Co., Limited, in respect of electrical material and plant for use in Lhasa, the capital city of Thibet. The inquiry originated in April, 1930, and called for the installation of step-up transformers, a 3,300-volt overhead line to a munition factory at Debchi, and for the extension of this line to Lhasa, a distance of three miles.

One understands that the electricity was required to drive the machinery in the munition factory during the day time and to supply light to Lhasa during the night.

As may be imagined, the transport problem presented some difficulties, since Lhasa is 400 miles from railhead, and is only approached with great difficulty by means of rough tracks through the mountains. Lhasa itself is 12,000 ft. up, and hence individual packages weighing not more than 80 lb. a piece were the order of the day. In all, 1,818 separate packages were sent through the mountains—one instance was that of a length of heavy cable 6,200 yards long. This had to be cut into 310 lengths of 20 yards each for transport, and rejoined by means of junction boxes when in situ.

The contract is of peculiar interest, since one has always been accustomed to regard Lhasa as the "Forbidden City"—certainly the G.E.C. are to be congratulated upon the manner in which they overcame the many difficulties set in their path.

G.V.D and L.M.S.

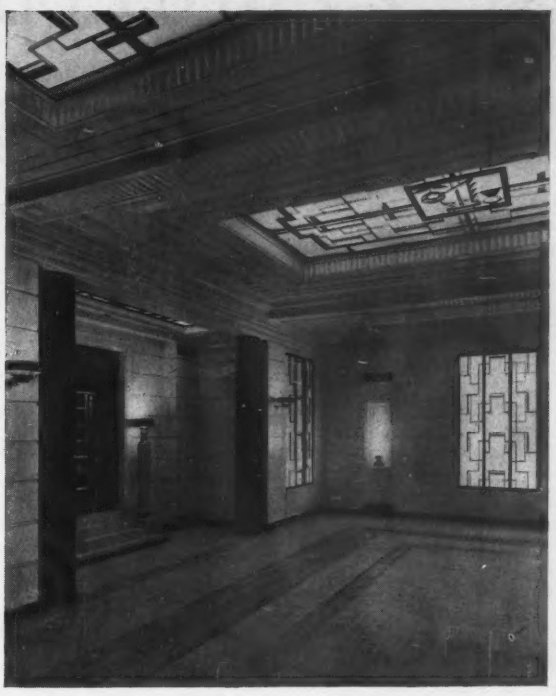
THE use of Light for both decorative and utility purposes is seen to advantage in the new Central Enquiry Bureau at Euston House. The whole of the

ARCHITECTURAL LIGHTING

—seven lay-lights and five windows—was entrusted to G.V.D. Illuminators.

As an example of the economies of G.V.D. Lighting it may be mentioned that each of the windows, which measure 10 ft. 6 ins. x 5 ft. 6 ins., is illuminated by only two 200-watt bulbs.

The G.V.D. System offers considerable advantages in all classes of illumination and the fullest co-operation is offered in the planning of installations for every requirement.



Demonstration units may be seen at our Showrooms or a descriptive CATALOGUE will gladly be sent upon request.

G.V.D. ILLUMINATORS
(G. V. DOWNER)
ALDWYCH HOUSE, ALDWYCH, LONDON, W.C.2
Telephone: Holborn 8879.

Central Enquiry Bureau EUSTON HOUSE, N.W.1. Architects: A. V. Heal, Esq., F.R.I.B.A. and W. H. Hamlyn, Esq., A.R.I.B.A.

Trade Notes—(*Cont.*)

Lighting at Cockfosters Station

With the opening up of the new through electric train service linking Uxbridge with Cockfosters on the London Underground system, it is opportune to refer to the elaborate lighting installation which is now in operation at Cockfosters Station and Depot.

The lighting of Cockfosters Station, which is a surface station, embodies several interesting features. The covered platforms are illuminated by means of 16 in. dia. G.E.C. Superlux spheres on a modern type of suspension, which permits the globe to be lowered for cleaning and lamp replacements without being detached. The open platforms are illuminated by means of half silvered 12 in. dia. spheres. The lower half is internally frosted and the result is a fitting which not only looks pleasing but has a very high efficiency and good light distribution.

The photograph we reproduce here shows the lighting up to advantage.

Contracts Closed

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Westhoughton U.D.C.—Contract for 12 months supplies of Osram Lamps.

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Metropolitan Borough of Islington—12 months supplies of Osram Lamps.

Plympton St. Mary, R.D.C.—12 months supplies of Osram Lamps.

Belfast Corporation Electricity Department—12 months supplies of Osram metal filament gas-filled and vacuum lamps, and Robertson Carbon filament Lamps.

SIEMENS ELECTRIC LAMPS AND SUPPLIES LIMITED.

Durham County Council Chester-le-Street—The supply of Electric Lamps for a period of six months.

THE EDISON SWAN ELECTRIC CO., LTD.

The War Office.—Contract from the War Office for the supply of lamps for one year from April 29, 1934.

CORRESPONDENCE

To the Editor.

"PHOTOMETRY OF GASEOUS DISCHARGE LAMPS."

Dear Sir,

So many new problems have presented themselves to the Street Lighting Engineer in connection with the gaseous discharge lamp that their discussion in your columns should prove of interest. Given the new lamp, the Lighting Engineer has first to test it for candle-power and lumens to ensure that its rating is in order. This process is not so straightforward as testing Tungsten filament lamps, since the question of colour raises a difficulty. At first sight it would seem that a flicker photometer is desirable, but the flicker instrument is only suitable for high field brightness (25-metre candles) and, unless used with great care, is liable to give misleading results. The method most favoured is a straight comparison by means of, preferably, a Lummer-Brodhun Head. The colour difficulty can be minimised by using a coloured Comparison Lamp. The Comparison unit used by the writer consisted of a window of Ilford Diffusing Medium illuminated by a 25-watt opal lamp, which was modified by interposing a green glass, the green glass being moved so that the window appeared two-thirds green and one-third white. It is necessary to take the mean reading of a number of observers, as all eyes are not equally sensitive to colour.

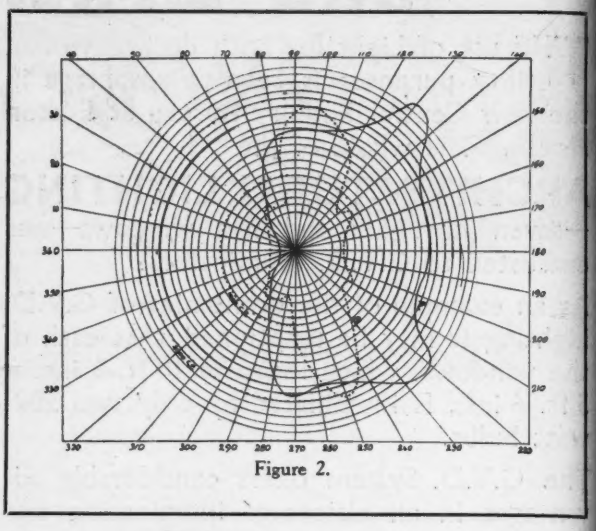
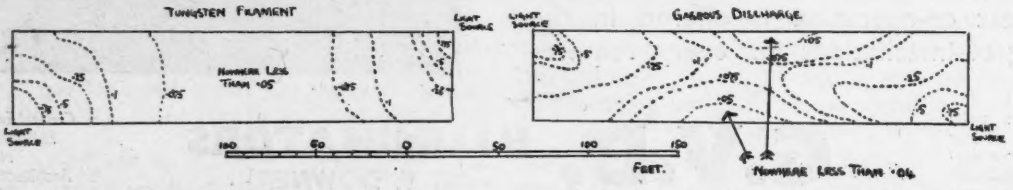


Figure 2.



It would be very interesting to know what results other readers have had. The writer has, for example, obtained a figure of 13,000 lumens at 420 watts for a lamp which had been in use for about fifty hours. This is well below the figure advertised as the "initial" lumen output for a particular make, and suggests that the lamps may very quickly diminish in brightness. Perhaps data are available on this subject, and may already be published.

The choice of a suitable housing in which to fit the lamp is the next important problem, and no doubt every engineer will wish to try the lamp in existing fittings. These must, of course, provide protection from the weather, whatever else they do. In scientific street lighting, polar curves are essential, and these may be very easily obtained by use of such an instrument as the Weston Illumination Meter, or other similar device. The only trouble is that the reading in foot-candles has to be corrected by a factor. This factor can easily be determined from the polar curve of the bare lamp. Knowing the lumens of the lamp, and calculating lumens from the polar curve, a ratio is established, and this ratio, when applied to readings, will give true candle power. The figure for the writer's instrument worked out at 15 per cent. (Readings to be increased by 15 per cent.)

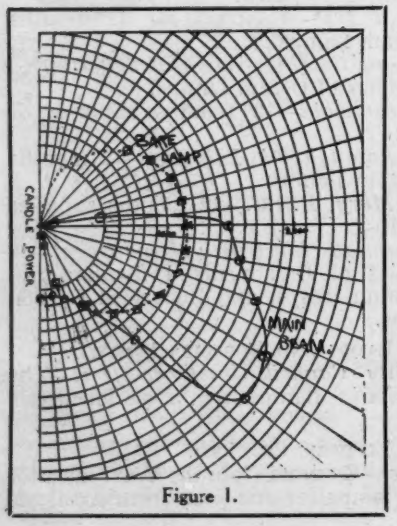


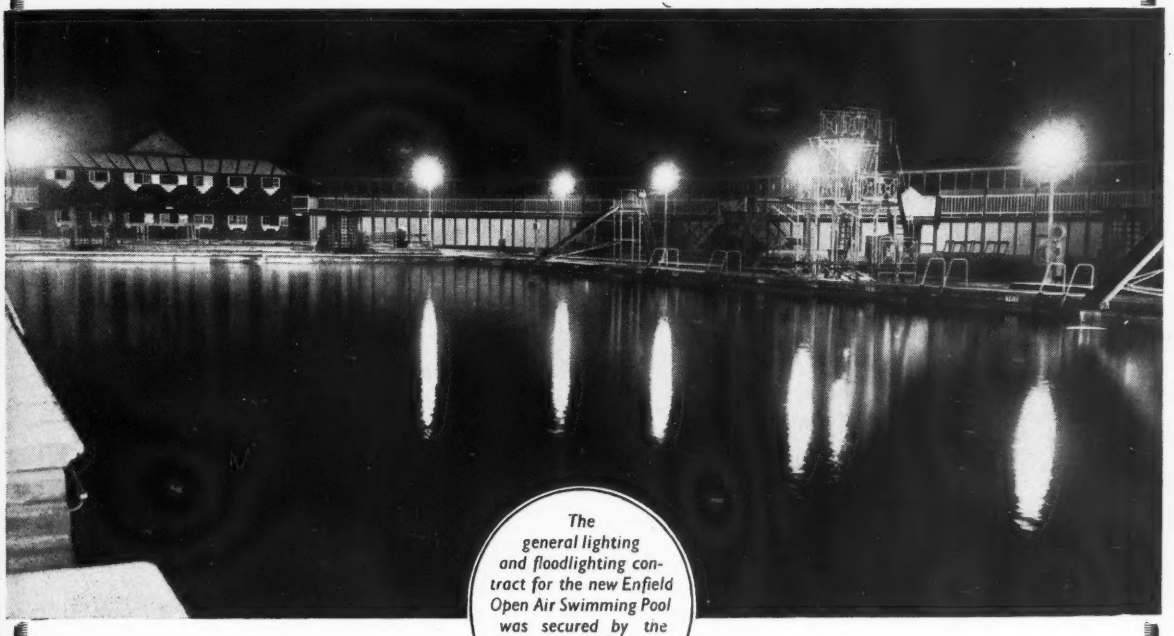
Figure 1.

Using this device for reading polar curves on fittings involves an error in neglecting the infra red and ultra violet response of the cell. When radiation passes through glassware, the invisible portion may be absorbed to a greater or less degree depending upon the properties of the glass and, in this way, a correction factor for the cell when used on the bare lamp no longer holds when the light passes through glassware. The new correction may be determined by a straight comparison of the cell with some visual method. A convenient method is to use the ordinary Lumeter, or other standard portable Photometer, for this purpose. It will be found that a reading is more easily obtained in the street than in the laboratory owing to the low field brightness, when the colour difference is not so obvious. The photo-electric cell gives the shape of the diagram, the scale being determined by some direct visual method. It is a curious fact that the relative brightness of the test plane to that of the photo-cell is not constant, but appears to increase as the field brightness is reduced. The low fields were obtained by means of a sheet of diffusing medium and iris diaphragm interposed between the source and the cell or test plane. The cell was illuminated to read approximately 3 foot-candles, while the test plane was situated further away, reading the low fields obtained in street lighting work. An illustration is shown of a polar curve obtained from a prismatic Glass Two-Way Non-Axial Bowl at 15 degrees below the horizontal, also a curve showing vertical distribution.

This fitting was adopted on a section of main road in Edinburgh, where it may be seen in contrast with 500-watt Tungsten Filament Lighting with prismatic glass bowls. The amount of light absorbed in the glassware is approximately 25 per cent. It is interesting to notice how similar the intensities of illumination are in the two cases shown, and yet there is very little doubt which stretch of roadway appears the more efficiently lit.

D. G. SANDEMAN, B.Sc., A.M.I.E.E.

GAS LIGHTING WON AGAIN HERE



The general lighting and floodlighting contract for the new Enfield Open Air Swimming Pool was secured by the Tottenham and District Gas Co. in open competition

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